

Adams, T.S. and Reinecke, J.F.

The Reproductive Physiology of the Screwworm, *Cochliomyia hominivorax*
(Diptera: Calliphoridae) I. Oogenesis

Attractants Workshop

1979 J. Med. Entomology 15: 472-83

Oogenesis in the screwworm fly, *Cochliomyia hominivorax*, was divided into a series of 10 stages, where the germarium was defined as stage 1, the beginning of yolk formation as stage 4, and the mature egg as stage 10. The volume of the nurse cell nuclei was maximum at stage 6 and then started to decrease. However, maximum cytoplasmic volume of the nurse cells was observed in stage 7 follicles. The nurse cells degenerated during stage 9. Chorion formation started in stage 9 follicles and was completed by stage 10. The number of follicle cells increased during stages 2, 3, and 4 and decreased during stages 6-10. The follicle cells over the nurse chamber were squamous during stages 6-9. During stages 6 and 7, the follicle cells over the oocyte were columnar; during stage 8, they were cuboidal, and during stages 9 and 10, they became elongated.

Adams, T.S., Holt, G.G., Sundet, W.D.

Physical and physiological effects on the response of female screwworms to carrion odors in an olfactometer

Attractants Workshop

1979 J. Med. Entomol. 15:124-131

An olfactometer bioassay was developed to study screwworm attractants in the laboratory. Maximum attractancy and activity in the olfactometer occurred at a wind speed of 1 m/s, a light intensity of 10.8 lx, a humidity of 50% RH, a temperature of 27 °C, and an exposure time of 15 min. The attractant source was a 25% solution of spent larval rearing medium (vat fluid) applied at a volume of 0.1 cm³ to a water-saturated dental roll. Flies fed on meat or blood were less attracted to vat fluid. It was concluded that vat fluid produced a feeding attractant.

Baumgartner, D.L. and Greenberg, B.

The Primary Screwworm Fly, *Cochliomyia Hominivorax* (Coquerel) (Diptera, Calliphoridae), in Peru

Attractants Workshop

1983 Rev. Brasil. de Biol. 43:215-221

Cochliomyia hominivorax larvae and adults were collected in hemi- and asynanthropic sites in the lower jungle near Puerto Bermudez and the upper jungle near San Ramon, areas with an emerging livestock industry. This is the first substantiated record of the primary screwworm from Peru. Among several baits tested, including Swormlure-2, only fish, liver, and human feces proved attractive. Swormlure-2 attracted no other blow flies, except a few *C. macellaria* and *Chloroprocta idioides*. *C. hominivorax* represented 1.8 percent (winter, Ft. Bermudez), 0.10 percent (summer, Pto. Bermudez), and 0.38 percent (summer, Pto. San Ramon) of the total blow flies collected. The myiasis wounds were small, circumscribed, odorless, had relatively few larvae, and healed quickly following insecticidal treatment. Genitalia of reared flies from two sites differ in epiphallus angle and apodeme shape. Important economic & biological questions are raised by these findings.

Bishopp, F.C., Carey, R.M., et al.

Flytraps and their operation of the Screwworm Attractant, Swormlure-2

Attractants Workshop

1916 USDA Farmers' Bull. 734 14 pp

Polyester fiber wicks in a crop line grain were superior to cotton seed Description and use of "Bishopp" trap used in trapping screwworms until the advent of the "wind oriented trap". The cotton seed was released the attractant rapidly due to evaporation over the entire surface area. The plastic wick released the attractant at a much slower rate because evaporation occurred only at the exposed ends. The use of plastic wicks in the Screwworm Adult Suppression System (SAS) units extended the effective life of these units by 3-fold over 1 hour being cotton wicks. The use of plastic wicks in reservoir bottles used in screwworm survey traps reduced the quantity of swormlure-2 required by 10-fold without reducing the number of screwworm flies captured. Traps with plastic wicks were easier and safer to service.

Broce, A.B., Goodenough, J.L., et al.

Sexual behavior of screwworm flies stimulated by swormlure-2

Attractants Workshop

1980 Ann. Entomol. Soc. Amer. 73:386-389

A new screwworm trap that catches the flies as they come flying toward Males of the screwworm fly, *Cochliomyia hominivorax*, were sexually stimulated by the chemical attractant swormlure-2, reaching a significant level of sexual response when 3 d old. Females started responding when 2 d old, but their responses did not appear to be sexually related. Males responded strongly to stimulation by some of the individual components of swormlure, namely sec-butyl alcohol, butyric acid, valeric acid, p-cresol, and indole. Females responded strongly to stimulation by dimethyl disulfide, p-cresol, and acetic acid. The biological significance of swormlure-2 in the behavior of screwworm flies is perhaps that it mimics the odor of an aggregation site (flowers).

Broce, A.B. and Ideker, J.L., Shaw, J.W.

Oleander Flowers as Insect Traps at various distances and directions of the attractant swormlure-2

Attractants Workshop

1978 Ann. Entomol. Soc. Amer. 71: 628-629

Flowers of oleander, *Nerium oleander* L., were found with insects trapped inside their corollas. Insects when collecting nectar, insert their mouth parts between stamens near the base of the pistil. When the mouth parts are withdrawn, the labella become lodged between adjacent sagittate anthers and trap the insects. The possible adaptive significance of this trapping phenomenon is discussed. Trapped insects consisted primarily of primary and secondary screwworm flies, *Cochliomyia hominivorax* (Coquerel and *C. macellaris* (F.), respectively, which comprised 88 % of all trapped flies. The high % of these flies in oleander was due to the high population density of these insects and the scarcity of other food sources. Flies dispersed at random from the release point and then were captured only after entering the flower. It was inferred that the odor of the oleander flower was of influence of swormlure for attraction and attraction of the flies.

swormlure for attraction and attraction of the flies. Flies entered 125-150 ft downwind of the release point.

Broce, A.B., Davey, R.B., et al.

Plastic Wicks as Dispensers of the Screwworm Attractant, Swormlure-2

Attractants Workshop

1979 J. Econ. Entomol. 72: 115-118

Polyester fiber wicks in a propylene skin were superior to cotton dental wicks as a slow release mechanism for the screwworm, *Cochliomyia hominivorax* (Coquerel), chemical attractant, swormlure-2. The cotton wicks released the attractant rapidly due to evaporation over the entire surface area. The plastic wicks released the swormlure-2 at a much slower rate because evaporation occurred only at the exposed ends. The use of plastic wicks in the Screwworm Adult Suppression System (SWASS) units extended the effective life of these units by 4-fold over those using cotton wicks. The use of plastic wicks in reservoir bottles used in screwworm survey traps reduced the quantity of swormlure-2 released by 10-fold without reducing the number of screwworm flies captured. Traps with plastic wicks were easier and safer to service.

Broce, A.B., Goodenough, J.L., et al.

A Wind Oriented Trap for Screwworm Flies

Attractants Workshop

1977 J. Econ. Entomol. 70: 413-416

A new screwworm trap that catches the flies as they move upwind toward the attractant, Swormlure-2, (SL-2), was developed. This wind oriented trap (WOT) maintains a constant orientation with the wind. It was field tested and compared with the standard blowfly trap (STT). The WOT caught more primary screwworm flies, *Cochliomyia hominivorax* (Coquerel), than the STT in every collection date and was better than or equal to the latter in every trapping site. The WOT caught a lower % (29) and number (7358) of secondary screwworm flies, *C. macellaria* (F.), than the STT (65% and 18906 flies). The WOT caught a lower % of males of both species but caught a greater number of *C. hominivorax* males. The WOT is more efficient in trapping *C. hominivorax* flies, easier to handle, and costs less than the STT.

Broce, A.B., Goodenough, J.L., Snow, J.W.

Recovery of screwworm flies released at various distances and directions of the attractant swormlure-2

Attractants Workshop

1979 Environ. Entomol. 8:824-828

Sterile screwworm flies dye-marked and released 50 m upwind and at both sides crosswind of the screwworm chemical attractant swormlure-2 were captured at rates of 13, 3, 27.4, and 14.3% respectively, of those released downwind of the attractant, indicating that flies moved in all directions immediately after release. When released at 9 distances, 50-350 m downwind of the attractant source, recaptures of flies released 50-125 m were initially high but decreased rapidly. Recaptures of flies released 150-350 m downwind of the attractant were initially low and remained ca constant. Flies released at 150 m and beyond, apparently first dispersed at random from the release point and then were captured only after entering the odor plume. It was inferred that the odor plume or instantaneous area of influence of swormlure for detection and attractancy by sterile screwworm flies extended 125-150 m downwind of the attractant source.

Bromel, M., Duh, F.M., et al.

Bacteria associated with the screwworm fly (*Cochliomyia hominivorax*) (Coquerel) and their metabolites

Attractants Workshop

1983

Endocytobiology

II:791-800

All stages of the life cycle and larval environments of the screwworm fly were subjected to bacteriological analysis. Samples of egg masses, larvae, pupae, adult flies, wound fluid from infested animals and vat rearing fluid were obtained from USDA Texas, Mexico or N. Dakota rearing facilities or from field collection in Texas and Mexico. Bacteria were isolated with standard bacteriological techniques and identified with computerized numerical identification systems. Highest counts were found in the laboratory reared larvae and field-collected pupal stages. Lowest counts were determined from the eggs. *Proteus mirabilis*, *Providencia stuartii* and *Providencia rettgeri* occurred as codominants in eggs, larvae, and pupae. *P. mirabilis* and *P. rettgeri* were the most frequently isolated species from larval growth environments. A bactericidal metabolite from all *P. mirabilis* isolates killed pyogenic bacteria (streptococci and staphylococci) in 4 min. Olfactometer studies indicated that culture media from *P. rettgeri* was attractive to gravid flies.

Brown, H.E. and Mackley, J.W.

Changes in Attractancy and Chemical Composition of the Screwworm Chemical Attractant, Swormlure-2, under Field Conditions

Attractants Workshop

1983

J. Econ. Entomol.

76: 1273-78

Swormlure-2 (SL-2), the chemical attractant of adult screwworms, was 17 to 56% more attractive during the 1st 5 d of field exposure than SL-2 exposed only 1 or 2 d. Attractancy declined steadily after 5 d, after 11 d, it was 50% as attractive. Sex ratios were not affected by changes in attractancy. 40.5% evaporated during 1st 5 days. Group I chemicals (iso-butanol, sec-butanol, dimethyl disulfide, acetic acid, butyric acid) exhibited high evaporation rates at the outset. Group II chems. (phenol, valeric acid, p-cresol, benzoic acid, indole) exhibited low, relatively constant evaporation rates and comprised 52.7% of the vapor as exposure time increased. Attractancy and Group I dosage were positively correlated but attract. and Group II dosage were not. Loss of attractancy may have resulted from increased Group II dosage. The loss, therefore, appeared to result from changes in composition, but not decreases in dosage of vapor. Temperature and wind were the main weather related factors affecting evaporation.

Coppedge, J.R. and Snow, J.W.

Seasonal response of screwworm adults to two attractants in subtropical Texas

Attractants Workshop

1977

Southwest. Entomologist

2:57-61

The seasonal occurrence of screwworm flies in subtropical Texas was investigated using traps baited with liver and with the chemical attractant "swormlure". Native and released female screwworm flies were captured in all of 52 weeks of the study period (Oct 31, 1974 to Nov 1, 1975). The peak capture of female screwworm flies was in April while the peak capture of native female screwworm flies was in October. In general, the native and released male screwworm flies responded to the traps in much the same pattern as the females although in lower numbers. The seasonal responses of female screwworms to decomposing liver and to swormlure were similar.

Coppedge, J.R., Ahrens, E., et al.

Field Comparisons of Liver and a New Chemical Mixture as Attractants for the Screwworm Fly

Attractants Workshop

1977 Environ. Entomol. 6: 66-68

A new mixture of the screwworm, *Cochliomyia hominivorax* (Coquerel), chemical attractant was prepared and evaluated under field conditions. This new mixture "Swormlure-2," proved to be more attractive to screwworms than the mixture presently being used and at least as attractive as decomposing liver. In general, more unmated female flies were attracted to Swormlure-2 than were attracted to liver. Also, Swormlure-2 appeared to be more attractive than liver to unmated females that were in early stages of egg development.

Coppedge, J.R., Ahrens, E.H., Snow, J.W.

Swormlure-2 baited traps for detection of native screwworm flies

Attractants Workshop

1978 J. Econ. Entomol. 71:573-575

A survey was conducted in 12 south Texas counties from Jan-Apr 1976 to evaluate swormlure-2 baited traps for detection of native screwworm flies. In 6 of the 12 test counties, native screwworms were caught before the 1st screwworm case was confirmed. In 3 of the remaining 6 counties, native screwworm flies were captured within 10 days after the 1st case was confirmed. In the other 3 counties, screwworm cases were reported several weeks prior to the 1st capture of flies. The information provided by this survey was used by program officials in the operation of the ongoing screwworm eradication program.

Coppedge, J.R., Broce, A.B., et al.

Development of a Bait System for Suppression of Adult Screwworms

Attractants Workshop

1978 J. Econ. Entomol. 71: 484-485

Through extensive field evaluations, a bait system (hereafter termed "SWASS" for Screwworm Adult Suppression System) was developed for adult *Cochliomyia hominivorax* (Coquerel). SWASS units were a 5.1-cm diam x 7.5-cm cardboard cylinder. Approximately 5 g of a mixture of Elmer's glue (52%), granulated sugar (32%), dried blood (14%), and dichlorvos (2%) were smeared down the center, and a dental roll, ca. 2.5 cm long impregnated with 2 ml of swormlure-2, was placed in the mixture in ca. the center of the cylinder. When SWASS units were first evaluated near the screwworm production plant, they attracted and killed hundreds of released screwworm flies/h. In other field evaluations, SWASS units appeared ca. 70% as effective as a standard trap and ca. 35% as effective as a wind oriented trap when numbers of flies attracted to each trapping system were compared over 1-wk periods. In a field test conducted on a local ranch, native screwworms were attracted and killed by SWASS, 75-80% of the native flies killed with baits were females.

Coppedge, J.R., Brown, H.E., et al.

Bait Stations for the Suppression of Screwworm Populations

Attractants Workshop

1981 J. Econ. Entomol. 74: 168-172

Bait stations were prepared and evaluated for field effectiveness against *C. hominivorax*. Each bait station consisted of a paper cone (15 cm diameter) covered on top with ca. 50 g of feeding bait-toxicant mixture (dried blood, sugar Elmer's glue, dichlorvos) suspended over a cup of solidified swormlure-2 (75% swormlure-2, 25% American Hoetsch KSL wax). In the initial field evaluation, bait stations were equal in effectiveness to wind-oriented traps for killing or capturing screwworms, and were 6 X more effective against secondary screwworms, *C. macellaria*. Chemical assay indicated that bait stations should attract and kill screwworm flies for 45 - 60 da. In 2 other field tests, the toxicant in the bait stations was replaced with sodium fluorescein dye. In the 1st test, bait stations were placed in groups of 4 near live-stock watering areas; 18% of *C.h.* and 20% of *C.m.* captured during 30 da were dye marked. In the 2nd test bait stations were placed at random and 25% of *C.h.* and 31% of *C.m.* were dye marked.

Coppedge, J.R., Goodenough, J.L., et al.

Evaluation of the Screwworm Adult Suppression System (SWASS) on the Island of Curacao

Attractants Workshop

1978 J. Econ. Entomol. 71: 579-584

SWASS a bait-toxicant system for the screwworm was evaluated on the island of Curacao, Netherlands Antilles. The SWASS units (individual (individual components of the screwworm adult suppression system) were dispersed (10-20/km²) by air over th rural part of the island and by ground (10-20/km²) within its urban areas for a period of ca. 15 wk Feb. 26-May 13, 1977. Collection of adults in survey traps indicated a 65-85% suppression. Reported larval incidence declined 30-70% from that expected. There was an increase in the proportion of males captured in the traps during th period that SWASS units were in the field which reflected the 1 male:5 female kill ratio characteristic of SWASS. In mid-May, the distribution of SWASS was discontinued and releases of sterile flies (1575/km²) were initiated. The releases reduced the residual population of screwworms to insignificant numbers in 3-4 wk, and the island was declared screwworm free on Oct 25, 1977, when over 3 mo had passed without an infested animal being reported.

Crystal, M.M.

Observations on the Role of Light, Temperature, Age, and Sex in the Response of Screwworm Flies to Attractants

Attractants Workshop

1964 J. Econ. Entomol. 57: 324-325

Observations made while screening candidate attractants for the screwworm fly, *Cochliomyia hominivorax* (Coquerel), revealed that light was an environmental factor affecting fly response. In unbaited traps about 25 times more flies were captured in light than in darkness. At temperatures ranging from 86-113 F, 3 times as many flies were captured as at those from 67-80 . Oviposition took place in temperatures ranging from 86-113; the greatest number of egg masses were deposited at 104- + 6. In baited traps very few 1- to 2-day old flies were captured among 1- to 7-day-old flies tested; the greatest attraction was obtained when the flies were 3-4 days old. Among flies 6-8 days old tested for their attraction to liver and blood, about 5 times more females than males were trapped.

DeVaney, J.A., Eddy, G.W., Ellis, E., Harrington
Attractancy of inoculated and incubated bovine blood fractions to
screwworm flies: Role of bacteria
Attractants Workshop
1973 J. Med. Entomol. 10:591-595

Olfactometer tests in the laboratory with bacteria-contaminated citrated whole bovine blood, bacteria-inoculated sterile citrated whole blood, defibrinated blood, and blood plasma indicated that the attractancy of these materials to screwworm flies resulted from the bacteria and/or from the compounds produced by them. Aseptically drawn blood incubated at 37 °C for 7 days was no more attractive than the unincubated blood held at 5 °C. Ranking of attractiveness was bacteria-inoculated sterile defibrinated blood > bacteria-inoculated citrated whole blood > bacteria-inoculated plasma > sterile-incubated defibrinated blood = distilled water.

DeVaney, J.A., Eddy, G.W., et al.
Olfactory Responses of the Adult Screwworm After Removal of the
Antennae, Mouthparts, Tarsi and Legs
Attractants Workshop
1970 J. Econ. Entomol. 63: 1816-19

The removal of certain appendages or segments from adult screwworms and subsequent tests of oviposition, response to baited and unbaited traps, and response to screwworm infested wounds on sheep showed that the more important olfactory receptors are situated on antennae and mouthparts. Removal of only 1 appendage did not reduce egg production drastically, but when both the antennae and mouthparts were removed only 21% of the flies laid egg masses (compared with 93% in controls). Little oviposition occurred when the "antennaless" flies were separate from the eggging medium; also these flies didn't discriminate between baited and unbaited traps, nor were they able to locate infested wound. Flies having only 1 antenna removed were able to locate baited traps and infested wounds, but not nearly so well as normal flies. Flies with excised mouthparts responded like normal flies to baited and unbaited traps. The precise location of receptors was not determined but results indicate the necessity of using intact specimens.

DeVaney, J.A., Eddy, G.W., et al.
Response of Three Colonies of Screwworm Flies to Proteins and Sugars
in a Multiple-Choice Olfactometer
Attractants Workshop
1971 J. Econ. Entomol. 64: 809-812

When responses of 3 colonies of *Cochliomyia hominivorax* (Coquerel) to 10% aqueous preparations of egg albumin, casein hydrolysate, raffinose, or dextrose were tested in a new multiple-choice olfactometer, the 2 laboratory-adapted colonies responded similarly based on the number of flies trapped. However, flies from a more recently colonized group were less responsive, especially when they were less than 5 days old. The colonies did not show a marked preference for any material, nor was response correlated with either sex or age. Improvements in the olfactometer must be made before it would prove satisfactory for screening materials as attractants for the screwworm fly.

Eddy, G.W., DeVaney, J.A., Handke, B.D., Lopez

Attractants for the screwworm : Irradiation effects on bacteria-inoculated media

Attractants Workshop

1975

Ann. Entomol. Soc. Amer.

68:269-270

A dose of 2000 krad was required to kill bacteria in media prepared from homogenized 3rd-instar screwworm larvae and in sterile whole and defibrinated blood. The production of substances attractive to screwworm flies was reduced when the media were irradiated at 20 krad in ⁶⁰Co gamma ray source. However, blood irradiated at 20 krad then inoculated and incubated was more attractive than unirradiated and incubated blood.

Eisemann, C.H. and Rice, M.J.

The origin of sheep blowfly, *Lucilia cuprina* (Diptera: Calliphoridae), attractants in media infested with larvae

Attractants Workshop

1987

Bull. Entomol. Res.

77:287-294

Laboratory bioassays with gravid females of *Lucilia cuprina* were used to isolate the source(s) of olfactory attractants emanating from larvae infested media. Adults were not attracted by odours from axenic (microorganism-free) larvae, but volatiles from xenic larvae were highly attractive. The attractants proved to be kairomones, not pheromones, as odours from other species of calliphorids and a sarcophagid species were also attractive.....The order of attractiveness was: xenic with larvae >> xenic without larvae > axenic with larvae > axenic without larvae. It is concluded that larvae infested media owe their great attractiveness to the volatiles produced by the action of microorganisms, not to specific larval volatiles. Larval activity accentuates the output of attractive volatiles from both xenic & axenic proteinaceous media.

Flath, R.A., Mon, T.R., Whitten, C.J., et al.

Volatile Components of *Acacia* sp. Blossoms

Attractants Workshop

1983

J. Agric. Food Chem.

31: 1167-70

Volatile component mixtures from the blossoms of three different *Acacia* sp. were examined and compared by capillary gas chromatography/mass spectrometry. Blossoms of *Acacia berlandieri* Benth. and *Acacia rigidula* Benth. are attractive to the screwworm fly *Cochliomyia hominivorax* (Coquerel), while those of *Acacia farnesiana* (L.) Willd. are inactive. A total of 114 compounds was identified in the three concentrates. Fourteen of these were found in concentrates from the two active species but could not be detected in the volatile concentrate from *A. farnesiana* blossoms. They include trans-5-ethenyl-tetrahydro-a,a,5-trimethyl-2-furanmethanol (linalool oxide A), 2-phenylethanol, trans,cis-2-6-nonadien-1-ol, cis-6-ethenyltetrahydro-2,2,6-trimethyl-2H-pyran-3-ol (linalool oxide D), 1-nonanol, 1H-indole, trans,trans-2-4-nonadienal, eugenol, benzyl 2-methylbutyrate, jasmone, geranylacetone, cis-3-hexenyl benzoate, hexyl benzoate, and benzyl salicylate.

Fletcher, L.W. and Turner, J.P.

Response of Female Screwworm Flies to a Selected Odor & time-interval
grid trap and correlation with temperature

Attractants Workshop

1973 Ann. Entomol. Soc. Am. 64-85-1973

The diminishing effect on female *Cochliomyia hominivorax* (Coquerel) exposed for short periods to the odor(s) of fermented blood albumin in a field cage that indicated habituation as demonstrated by a waning in response, may have occurred. Even when the interval between tests with the same flies and odors was lengthened from 15 to 75 to 120 minutes, complete recovery did not occur. However, at least 120 minutes were required between test before significant results could be obtained. Female screwworm flies did not respond to the odor(s) unless the minimum temperature was 17.8 C.

Fletcher, L.W., Turner, J.P., Husman, C.N.

Surface temperature as a factor in the selection of ovipositional sites by three strains of the screwworm

Attractants Workshop

1973 J. Econ. Entomol. 66:422-423

A test chamber with a controlled heat gradient was used to determine surface temperature effects on selection of ovipositional sites by screwworm flies. Range was 30.6 to 36.7 oC. The greatest number oviposited at 33.3 oC. Preferred range was 33.3 +/- 1 oC.

Foss, D.K., McDonald, I.C., Bromel, M., Gassner

Isozyme variation among bacterial isolates originating from the screwworm fly

Attractants Workshop

1983 Environ. Entomol. 12:1773-81

Isozyme surveys were used to compare genetic variation within and among strains of the bacterium *Proteus rettgeri*. 1 strain was a standard American Type Cell Culture strain, whereas 8 other strains were recovered from larva or pupa of the screwworm of varied geographic or animal host origins. Observations of 16 different enzyme systems of each bacterial isolate revealed extensive inter- & intrastrain variation in the numbers or positions of enzyme bands recorded among samples from different phases of culture growth media. Similar differences were likewise noted among strains when they were sampled at the same growth phase. Hierarchical clustering and multidimensional analyses of the data produced groupings of the bacterial strains which suggested that their enzyme patterns were influenced by factors related to their geographic distribution or their animal host origins.

Goodenough, J.L. and Snow, J.W.

Capture of screwworm and secondary screwworm flies in a time-interval grid trap and correlation with temperature

Attractants Workshop

1979 J. Med. Entomol. 16: 95-103

A time-interval electrocutor grid trap was successfully modified to collect adult screwworms, *C. hominivorax*, and secondary screwworms, *C. macellaria*, during 14 hourly diurnal periods. Peak captures of *C. h.* were made in the am but collections of *C. m.* were made in larger and more uniform numbers throughout the day. Total numbers and activity patterns were highly variable day to day. Hourly captures of both spp were positively correlated with increasing temp. in the range of 20 - 33 oC. *C. h.* capture was very low below 20 oC, peaked ca 33 C, and appeared to decrease above 33 C. *C. m.* were detected over a greater temp range, possibly because they were present at much higher numbers. Captures of *C. m.* did not decrease between 33-35 C. A high degree of variation occurred in diurnal pattern of fly activity and nos. trapped even between successive days having identical temp and RH patterns. Relative humidity did not appear to influence captures, except that captures were zero or extremely low during rains.

Grabbe, R.R. and Turner, J.P.

Screwworm attractants: isolation and identification of organic compounds from bacterially inoculated and incubated blood

Attractants Workshop

1973 Folia Entomologia (Abst) 25-26:120-1

Isolation and identification of organic compounds from bacterially inoculated and incubated blood. Ether extract was distilled & fractionated chemically to neutral, acidic, & basic fractions. Neutral fraction was most attractive and was fractionated by prep GLC. Fractions always had less activity than the total neutral mixture which was also passed through GLC. Compounds isolated & identified by infrared spectra & GLC retention time include phenol, p-cresol, & indole. Compounds tentatively identified include skatole & ethanethiol. Although the pure individual compounds were not very attractive at any concentration in aqueous solution or neat, dilute aqueous mixtures of indole, skatole, phenol, and p-cresol were quite attractive to screw-worm flies in the lab. The concentration arbitrarily used were 10 mg of each compound in 50 ml of water.

Guillot, F.S., Brown, H.E., et al.

Behavior of Sexually Active Male Screwworm Flies

Attractants Workshop

1978 Ann. Entomol. Soc. Amer. 71: 199-201

Sexually active male screwworms were observed in "waiting stations" from which they darted at any insect flying by. They often returned to the original station or a few cm from it without contacting the intruder. When they did make contact, the encounters were usually characterized by a vigorous wrestling, with the result that the pair of insects fell to the ground and parted. Occasionally, when the encounter involved a female screwworm fly, the pair flew off with the male holding the females's dorsum to a nearby limb where they mated. Males and virgin females were less likely to orient to a host animals than were mated females and were more abundant in vegetation. We suggest that males are more likely to encounter a receptive female from waiting station in vegetation where both sexes feed on nectar or honeydew, than from those on or near hosts.

Guillot, F.S., Coppedge, J.R., et al.

Behavior and Reproductive Status of Native Female Screwworms Attracted to a Host

Attractants Workshop

1977 Ann. Entomol. Soc. Am. 70:588-590

Female screwworms, *Cochliomyia hominivorax* (Coquerel), responding to a wounded host began to feed immediately on the wound exudate regardless of their stage of ovarian development. This behavior was probably related to nutritional requirements for egg maturation. The rather high abundance of vitellogenic, parous females throughout the year may be indicative of limited autogeny. The incidence of mating of females responding to wounds was 100% & 91% for parous and nulliparous females, respectively. Virgin nulliparous females were first captured in Sept. Mating probably occurs when a female screwworm is in the beginning stages of the first gonotrophic cycle.

Guillot, F.S., Coppedge, J.R., et al.

Reproductive Status of Female Screwworms Captured from Hosts or in Traps

Attractants Workshop

1977 Southwest. Entomologist 2: 49-52

Traps baited with liver or a chemical attractant captured fewer post-vitellogenic female screwworms, *Cochliomyia hominivorax* (Coquerel), & more females in the early stages of vitellogenesis than were captured from a host. In addition, more virgin vitellogenic nullipars were captured with baits. The chemical attractant is an effective tool for surveying a reproductively young population of screwworm females during winter when reports of infestations are infrequent.

Hammack, L., Fromel, M., Ehn, F.M., Sawyer, U.

Relationships of larval rearing variables to fly attraction and oviposition responses in the screwworm, *Cochliomyia hominivorax*

Attractants Workshop

1984 J. Med. Entomol. 21:351-356

Responsiveness of gravid screwworm flies in oviposition and olfactometer bioassays was examined in relation to mean larval wt, mean pupal wt, and survival to pupal stage in the larval rearing groups that supplied the test females. Weights were not of value for predicting adult behavior in bioassays, but the % of insects surviving from egg to pupal stage was positively and linearly correlated with oviposition and attraction responses ($r^2 = 0.48$ and 0.57 , respectively)..... Survival in larval groups did not vary with parental age at oviposition or with the temp at which parental insects had been held as pupae but circumstantial evidence suggested that composition of the larval starting diet affected survival and adult behavior.

Hammack, L.

Protein feeding and oviposition effects on attraction of screwworm flies (Diptera: Calliphoridae) to host fluids

Attractants Workshop

1989 Ann. Entomol. Soc. Amer. submitted

Olfactometers were used to study effects of protein feeding & oviposition on attraction of screwworm flies to host blood and wound fluids. The size of the protein meal taken at various physiological stages & the temporal relationship between feeding & oviposition were examined. Engorgement accompanied oviposition on a proteinaceous substrate, & ca 80% of time feeding in association with oviposition occurred during & immed. after egg-laying. Oviposition with feeding reduced attraction, oviposition did not. Protein feeding 60-90 min before bioassay reduced attraction of vitellogenic nullipars but not gravid; reduced gravid responsiveness was detected 30 min after feeding. Pattern correlated with the reluctance of gravid, unlike vitellogenics or those that oviposited, to engorge fully. The rapidity with which engorgement followed ovip. suggested that gravid are protein hungry. The tests confirmed existence of a screwworm feeding attractant & showed how such a might attract both non-gravids & gravid seeking ovipositional sites.

Hammack, L. and Holt, G.G.

Responses of gravid screwworm flies to whole wounds, wound fluid, and a standard blood attractant in olfactometer tests

Attractants Workshop

1983 J. Chem. Ecology 9: 913-922

Laboratory olfactometer bioassays were used to study attractiveness of whole animal wounds, wound fluid, and reconstituted dried blood to gravid screwworm flies, *Cochliomya hominivorax* (Coquerel). Flies were attracted to odors from whole wounds that were infested with screwworm larvae but not to those from uninfested wounds that were 0-2 days old. A maximum of 59% of females were attracted to fluid from screwworm infested wounds and the response changed little over fluid concentrations from 3.3 to 100%. However, blood tested over a similar concentration range yielded a significant linear relationship between log dose and response. Peak attraction was 82%. Attractancy of fluid collected from infested wounds declined when the fluid was stored at -20 C for more than four weeks but attractancy of a stored blood sample remained unchanged from three months. The blood attractant(s) was also heat stable and is suitable for use as a reference standard in bioassays.

Hammack, L., Bromel, M., Duh, F.M., Gassner, G.

Reproductive factors affecting responses of the screwworm fly, *Cochliomyia hominivorax*, to an attractant of bacterial origin

Attractants Workshop

1987 Ann. Entomol. Soc. Amer. 80:775-780

Attraction of screwworm flies, *C. hominivorax*, to steam distillate of culture medium inoculated with the bacterium, *Providencia rettgeri*, was studied in laboratory olfactometer assays conducted with 0- to 12-day old males and nulliparous females. Males, and females with previtellogenic ovaries, were not attracted. Those with vitellogenic ovaries demonstrated only a trace response. Females became gravid as early as 4-5 days, but the percentage of gravid females attracted increased linearly with age up to 10 d. Insemination significantly enhanced responsiveness without affecting the rate of ovarian development. Gravid mated females 10-12 d old were the most strongly attracted. The results were consistent with the hypothesis that bacterial metabolites contribute to the attractiveness of wounds on screwworm host animals.

Hightower, B.G.

Nocturnal Resting Places of the Screwworm Fly

Attractants Workshop

1963

J. Econ. Entomol.

56: 498-500

Large numbers of screwworm flies (*Cochliomyia hominivorax* (Coquerel)) marked with tracing powder fluorescent under ultraviolet light were released in the field in the afternoons and recovered during systematic searches on following nights. Flies tended to congregate at streams and pens of livestock, but recoveries from even the most favored locations were not large. More than 90% of recovered flies were found resting on small leafless twigs in low-canopy trees.

Hightower, B.G. and Adams, A.L.

Dispersal and Local Distribution of Laboratory-Reared Sterile Screwworm Flies Released in Winter

Attractants Workshop

1969

J. Econ. Entomol.

62: 259-261

In using the sterile-male technique to eradicate the screwworm from the southwestern U.S., emphasis has been placed on eliminating infestations in areas where the species could overwinter. Since the critical thermal average for survival for any life stage of the screwworm is 10 degrees C for 3 successive months, infestations occurred in the large area in Texas that is normally south of this isotherm throughout the year. Thus, sterile flies must be released during periods when the temperature is often below 16 C, about the threshold for wild fly activity. The relative rate of initial dispersal of sterile flies is slower but the pattern of local distribution is similar to the pattern in spring and summer.

Hightower, B.G. and Alley, D.A.

Local Distribution of Released Laboratory-Reared Screwworm Flies in Relation to Water Sources

Attractants Workshop

1963

J. Econ. Entomol.

56: 798-802

Two series of field release of marked laboratory-reared screwworm flies, *Cochliomyia hominivorax* (Coquerel), were carried out in southwest and central Texas to determine the local distribution of the flies in relation to stock ponds and streams. According to samples based on liver-baited trap catches, flies released in a semi-arid brushy area with no running streams tended to congregate around stock ponds. Flies released in an area crossed by running streams continued to disperse beyond a stream 0.8 to 1 mile from the release point to points on a second stream up to 1 mile beyond the first stream. Evidence is presented that the flies were channeled to some traps by terrain features. Local concentrations of flies on the stream nearest the release point persisted for 3 to 4 days. Peak catches of flies were noted on the third day following release. During the hot dry weather of late summer flies could not be detected along either stream.

Holt, G.G., Adams, T.S., et al.

Attraction and Ovipositional Response of Screwworms, *Cochliomyia hominivorax* (Diptera: calliphoridae), To Simulated Bovine Wounds
Attractants Workshop
1979 J. Med. Entomol. 16: 248-253

An olfactometer oviposition bioassay was developed to study behavior of the screwworm fly, *Cochliomyia hominivorax*, in the laboratory. Maximum oviposition (95.5%) occurred when females contacted bovine blood heated to 40 d C; also, bovine blood had the lowest mean attractance (10.3%) in olfactometer tests. Contact with all test material was necessary to stimulate oviposition. Vat fluid (incubated larval medium containing meat-blood mixture contaminated with larval waste products and microorganisms) had an attractance of 80.3% but inhibited oviposition at a concentration of stimulants were important factors that affected both the attractancy of the test materials and oviposition in the screwworm fly.

Jones, C.M., Dehler, D.D. et al.

A Chemical Attractant for Screwworm Flies

Attractants Workshop

1976 J. Econ. Entomol. 69: 389-391

A chemical bait that was as attractive as liver to adult *Cochliomyia hominivorax* (Coquerel) contained 10 chemicals found to be degradation products of animal protein. Best results were obtained by separating the chemicals to 3 vials based on compatibility. In a 20-wk comparison of the chemical bait with liver, the bait attracted 5.7 times more male screwworms, and the liver attracted 1.7 times more females and 7.7 times more trash flies.

Krafsur, E.S.

Aggregations of male screwworm flies, *Cochliomyia hominivorax* (Coquerel) in south Texas (DIPTERA: CALLIPHORIDAE)

Attractants Workshop

1978 Proc. Entomol. Soc. Wash 80:164-170

Noted for the 1st time is the occurrence of aggregations of males of the screwworm fly. The continuous presence of males in each of 2 sites in south Texas was independent of the presence of cattle or of female screwworm flies. Males captured in autumn 1975 proved to be wild; those captured in spring 1976 were released, sterile insects. The behavior of males, wild or sterile, included vigorous conspecific and interspecific interactions. There was evidence of territoriality and competition for favored perching sites. The observations are consistent with an hypothesis that the male screwworm aggregations were mating assemblies similar to those known among other cyclorhaphan Diptera. The significance of male aggregation to sterile fly liberations is discussed.

Mackley, J.W. and Brown, H.E.

Incidence of the screwworm, *Cochliomyia hominivorax*, and the secondary screwworm, *C. macellaria*, in the central highlands of Chiapas, Mexico
Attractants Workshop

1986 J. Med. Entomol. 23:76-82

In a 12 mo survey in the central highlands of Chiapas (470-2270m elev) 100 adult screwworms (0.058 adults/trap/wk) & 1155 adult *C. macellaria* (0.671 adult/trp/wk) were captured in wind-oriented traps baited with swormlure-2. Captures of the 2 spp were not correlated with elevation; instead adults appeared to occur in "pockets" along the altitudinal gradient. More adults were captured during the wet season than in the dry season; seasonal differences in captures were greater at elev. 1470-2270m than from 470-1270m. Adult capture rates (ACR) for screwworms were not correlated with ave mo temp or rainfall at low elev but showed a positive corr at high elev. These differences were believed to be due to greater annual changes in weather at high elevations. ACR's for *C. macellaria* were not correlated with the average monthly temperature or rainfall at either the high or low elev. Screwworm oviposition showed a negative correlation with elev., a possibly sig neg corr with ave. da precip, & pos corr with temperature.

Mackley, J.W. and Brown, H.E.

Swormlure-4: A new formulation of the swormlure-2 mixture as an attractant for adult screwworms, *Cochliomyia hominivorax*
Attractants Workshop

1984 J. Econ. Entomol. 77:1264-8

Fifteen candidate mixtures in which the ratios of the 10 components found in swormlure-2 (SL-2) were altered & compared with SL-2 for attractiveness to adult screwworms. The most attractive mixture (SL-4) differed from SL-2 in that it contained higher amounts of the components with the 4 lowest boiling points (bp) and lower amounts of the comp. with the 6 highest bp. Wind-oriented (WO) traps baited with SL-4 captured 40 & 81% more sterile and wild screwworm flies respectively, than SL-2 baited WO traps. Sex ratios for sterile & wild flies captured in SL-4 & SL-2 traps were similar. SL-4 captured 19% more *C. macellaria* & 28% more "other diptera". SL-4 was almost 2X as volatile as SL-2. Dosage & response for SL-4 & SL-2, respectively, showed some positive correlations; we concluded that both the new composition & higher dosage were responsible for the increased attractiveness of SL-4.

Mackley, J.W. and Long, G.L.

Behavior of sterile adult screwworms (Diptera: Calliphoridae) on flowering trees and shrubs

Attractants Workshop

1983 Ann. Entomol. Soc. Amer. 76:839-843

In a south Texas shrub and brush community, sterile adult screwworms were observed or collected on 19 of the 23 sampled species of flowering shrubs and trees. Flies were observed feeding, mating, and resting on flowering shrubs and trees. Most of the flies were found on tenaza, coyotillo, and certain *Acacia* spp, but not on flowering cacti, herbaceous wild flowers or grasses. Fly activity on a given plant species appeared to be related to blooming patterns and possibly flower color, but activity was not correlated to the density, frequency, or % coverage of a plant sp. Fewer females were collected (46.1%) and < 1/2 were mated. Flies appeared to aggregate, feed, and mate at local flowering vegetation for up to 5 days after eclosion.. No activity other than resting was observed when plants were not in flower, except at 2 locations where males were waiting for females on nonflowering veg. The effect of season & rainfall on flowering could have indirectly affected activity, particularly survival, as flowers are major feeding sites

Mackley, J.W. and Snow, J.W.

Effects of Cattle Dung on the Behavior and Survival of Adult
Screwworms and on the Development of their Eggs

Attractants Workshop

1982

Environ. Entomol.

11: 432-435

Fifty-six percent of sterile adult screwworms, *Cochliomyia hominivorax* (Coquerel), collected with a sweep net from cattle dung and vegetation at cattle-congregating areas in South Texas were mated females. No mating activity was observed at these sources. Collections from a wind-oriented trap baited with swormlure-2 and from dung yielded 3.7 and 11.6% males, respectively; these sex ratios were considered similar enough to suggest that some chemical components of swormlure-2 and dung may be related. Aging of dung reduces its attractiveness. Dung contributes little to screwworm survival and is an inadequate nutritional source for egg development in the second gonotrophic cycle. Dung may aid females in locating potential hosts.

Peterson, R.D., Mackley, J.W., Candido, A.O.

Sugar feeding by adult screwworms and its effect on longevity and
oocyte maturation

Attractants Workshop

1987

Ann. Entomol. Soc. Amer.

80:130-135

Because primary feeding by the screwworm on carbohydrate sources is essential to survival and reproductive success, we undertook studies to determine in the lab the feeding preferences for 0.1 and 0.3 M sugar solutions and their effect on longevity and oocyte maturation. Fertile flies 2-10 d old were fed 0.1 M sol. of either sucrose, fructose, glucose, maltose, or lactose. There was no significant difference between males in their consumption of sucrose and maltose. Females preferred maltose to sucrose. Glucose and lactose were least preferred by both sexes. Flies fed 0.1 M fructose showed the greatest median survival of 19 d, comparable with that of honey. Except for lactose survival was greater with increase in conc. Overall flies survived longer on honey than on the test sugars. None of the 0.1 M solutions were adequate for females to develop eggs to a mean stage of 10. Females fed 0.3 M maltose, sucrose and fructose developed mature eggs by age 10 d. Honey was superior for egg maturation.

Peterson, R.D. II

Influence of Trap Color and Height Above Ground on Capture of
Screwworms

Attractants Workshop

1982

Southwest. Entomologist

7: 240-243

Studies were conducted in South Texas and in Sinaloa, Mexico to determine the influence of trap color and height above ground on the capture of screwworms in wind oriented traps. In the color preference test, the overall distribution of trapped, *Cochliomyia hominivorax* (Coquerel), was yellow (24%), standard (22%), white (21%), green (16%), black (9%) and red (8%). There were 2X more females caught/trap/day in single traps hung 0.40 m above ground than in traps hung at the standard height of 1.5 m.

Peterson, R.D.II, McInnis, D.O., Whitten, C.J.

Dispersal and Distribution of Ground Released Screwworms *Cochliomyia hominivorax* (Diptera: Calliphoridae) in South Texas
Attractants Workshop

1983 APHIS Series. 91-57 11 pp

In 1980, 2 mark-release-recaptures of ground released adult screwworms *Cochliomyia hominivorax* Coquerel, were made at the King and Novillos ranches in south Texas to study dispersal patterns of the sterile flies. During the first release, drought conditions (temp. 38 C mean max, precipitation < 1mm) reduced trap captures. Only 0.53% of the flies released were recaptured, and of these, 87% collected the day following the release. Most flies at King were recaptured inside the 3 release blocks (65 km²), however 14% of the flies recaptured from 1 block release were captured outside the block. Dispersal patterns appeared to be correlated with wind direction. During release 1, flies moved with the 20 km/hr, S-E winds (prevailing 90% of the time) and some flies moved 12 km for a release point. No flies from north block release were captured the south block. Temperature moderation and rainfall (Hurricane Allen) made conditions more favorable for fly survival during the 2nd release.

Snow, J.W., Coppedge, J.R., Broce, A.B., et al.

Swormlure: Development and use in detection and suppression systems for adult screwworm (Diptera: Calliphoridae)
Attractants Workshop

1982 Bull. Entomol. Soc. Amer 28:277-284

A review of the development and uses of the chemical mixture known as swormlure through 1981. Includes the development and deployment of SWASS.

Spencer, J.P., Snow, J.W., Coppedge, Whitten

Seasonal occurrence of the primary & secondary screwworm in the Pacific coastal area of Chiapas, Mexico during 1978-1979
Attractants Workshop

1981 J. Med. Entomol. 18:240-243

During 1978 in the Pacific coastal area of Chiapas, Mexico, population of the primary screwworm, *Cochliomyia hominivorax*, reached seasonal highs in July & November-December and a seasonal low in April. Secondary screwworm, *C. macellaria*, population trends were similar, peaking in July & November with a seasonal low in March. Collection of egg masses from sheep showed a 98+% natural viability rate. Data from trap captures and sentinel animals indicate the presence of a resident population sufficient to provide the base for a buildup in screwworm infestation at any time during the year.

Spencer, J.P., Whitten, C.J., Coppedge, J., Snow
Comparison of screwworm captures in liver- and swormlure-baited traps
in a tropical area of southern Mexico
Attractants Workshop
1980 Southwest. Entomologist 5:175-178

In a field comparison conducted in a coastal area of Chiapas, Mexico, screen traps baited with liver and wind-oriented(WO) traps baited with swormlure-2 caught equal numbers of screwworms. However, the liver-baited traps caught significantly more *C. macellaria*, sarcophagid spp, and other miscellaneous flies than the WO traps, which greatly increased the time required for fly identification. In a 2nd test, plastic wicks and cotton wicks uses as swormlure-dispensers were equally effective in attracting female screwworms, but plastic wicks were significantly more effective in attracting screwworm males as evidenced by trap captures.

Spradbery, J.P.

The reproductive status of *Chrysomya* species (Diptera: Calliphoridae) attracted to liver-baited blowfly traps in Papua New Guinea
Attractants Workshop

1979 J. Aust. Entomol. Soc. 18:57-61

The reproductive status of 5 spp of *Chrysomya* caught in liver-baited traps in Papua was determined. The spp. trapped were *C. bezziana*, *C. megacephala*, *C. saffrana*, *C. rufifaces*, and *C. varipes*. Results were compared with data for *Lucilia cuprina* and *Cochliomyia hominivorax*. Of the total *Chrysomya* catch, only .04% were *bezziana*. Of the 108 *bezziana*, only 1 was male (17-26% males in other spp.). Demonstrates that the male *bezziana* is unresponsive to source of protein. Nulliparous females accounted for 9% of *bezziana* (53-76% for other spp.). This is related to the autogenous nature of the screwworm. Gravid females accounted for 12% of *bezziana* (21-50% of other spp.), 14% in *L. cuprina* and 5% in *C. hominivorax*. Of the 2nd ovarian cycle flies trapped, 98% of *bezziana* were in the early stages of egg development compared with 43-62% in the blowfly spp and *C. hominivorax*.

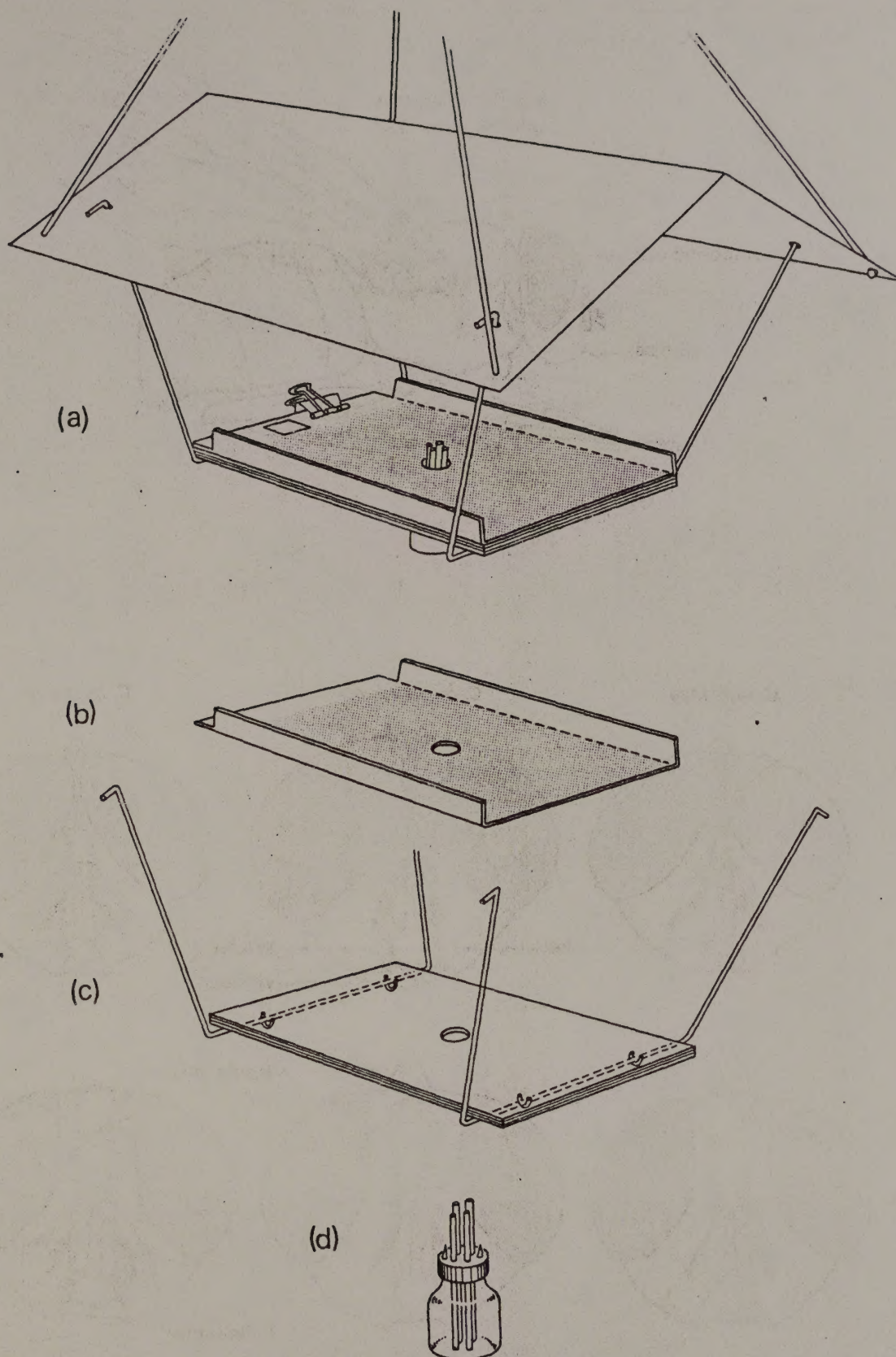
Thomas, D.B. and Mangan, R.L.

Oviposition and wound visiting behavior of the screwworm fly, *Cochliomyia hominivorax* (Coquerel)

Attractants Workshop

1989 Ann. Entomol. Soc. Amer. submitted

Female screwworms visit wounds of warm-blooded animals both to feed & to oviposit, with feeding occurring 2X as often as oviposition. Feeding avg. 5.4 min; oviposition avg. 15.4 min but visits for either may last up to 1 hr. Screwworms are iteroparous with ovip. occurring on a 3 da cycle. 1 female was recorded to live 33 da & ovip. 8X. Ovip activity by the population followed a 17-19 da cycle. Clutch size is variable from 28-492 eggs (mean = 200). Females deposit their clutch in 1-4 masses of eggs, usually on the margin of a wound. If a wound is preoccupied by an egg mass, an ovipositing female will place her egg mass on top of or in direct contact with the prior mass 67% of the time. Thus, the presumption of 1 egg mass equaling the reproductive output of a single female is invalid. Female screwworms combine longevity and iteroparity with autogeny and large clutches. This reproductive behavior is well adapted for exploitation of an ephemeral resource such as wounds on living animals.



5.10

Sticky trap. a) assembled trap, b) aluminium sheet with coating (stippled) of "tangle-trap" adhesive, c) plywood base with wire suspending arms attached by staples, d) "swormlure" dispensing bottle with 4 fibre wicks.

FROM: SPRADBERY, J.P. 1981
A new trap design for screw-worm studies
J. AUST. ENTOMOL. SOC. 20:151-153

Posted: Fri Jul 1, 1988 10:54 AM EDT

Msg: CGII-2651-2447

From: LC.FARGO

To: swr.fargo

CC: ggassner

Subj: Letter for Jim Whitten

George, This came in for Jim but there is no one out there right now to contact to have them read it off. I am not sure when Jim is coming back so I am sending you a copy also.
Viv.

Forwarded message:

Posted: Fri Jul 1, 1988 9:47 AM EDT

Msg: BGII-2651-1536

From: RBRAM

To: LC.FARGO

CC: RBRAM

Subj: Message for Jim Whitten

July 1, 1988

SUBJECT: Screwworm Attractants Workshop

TO: C. J. Whitten
Biosciences Res Lab, Fargo, ND

FROM: R. A. Bram
NPL, Insects Affecting Man & Animals and Parasitology

Thank you for your Telemail message of June 17 transmitting draft proposed agenda for subject workshop. Following are suggested modifications to what I consider to still be a DRAFT.

ARS Screwworm Attractants Workshop

OBJECTIVES: (1) To clarify the present status of screwworm attractants research; (2) to identify areas of research which will produce technologies applicable to the operational program; and (3) to identify needs for successful completion of this research.

PARTICIPANTS:	FARGO	MEXICO	OTHER
	Whitten	Mangan	Bram, NPS
	Hammack	Parker	Flath, WRRRC
	Peterson	Mackley, APHIS	Tumlinson, IABBBRL
	Pomonis	Hofmann, APHIS	
	Gassner	Gersabeck, APHIS	
		Ashley, APHIS	

AGENDA:

1st Half Day: Present Status of Screwworm Attractants Research
Swormlure Mackley/Whitten

Plant Attractants

Other (feeding, oviposition, etc.)

Peterson/Mangan/Parker

Mangan

2nd Half Day: Identify Areas of Research and Establish Priorities

3rd Half Day: Necessary Resources

Areas of Cooperation and Interaction

Workshop Summary

Of course, we still have to establish a date this fall, preferably before the snow starts to fall, and initiate the notification process. Please contact Bob Mangan when you get back and then give me a call.

Thanks.

Action?



United States
Department of
Agriculture

Agricultural
Research
Service

Pacific West Area

800 Buchanan Street
Albany, California
94710

August 24, 1988

SUBJECT: ARS Screwworm Attractants Workshop

TO: C. J. Whitten
Biosciences Research Laboratory
Fargo, ND

FROM: R. A. Flath *RF*
Western Regional Research Center
Albany, CA

Yesterday I received an invitation from Dr. Bram, NPS, to attend the Screwworm Attractants Workshop, to be held in Fargo on October 4-5. While still interested in the topic of screwworm fly attractants, I have been unable to find time to continue. I had indicated to Dr. Leslie Hammack that I would prepare fresh dried blood steam distillate and examine the volatile components by headspace GC/MS, since I have already done some preliminary work in this area in cooperation with her and Dr. Pomonis, but addition of several cooperative projects here in Albany have made this impossible for the present. I regret that for now I must set both the dried blood and the Acacia spp. work on a back burner.

Because of this situation, I will not be planning to attend the Workshop. As an aside, our discretionary funds are nearly non-existent in any case, so any travel is difficult.

cc:

R. Bram
L. Jurd
L. Hammack
G. Pomonis
G. Gassner

415-559-5807

Action can only refer to current message.

Action?

Command?

Posted: Thu Sep 1, 1988 2:53 PM EDT

Msg: KGII-2688-1975

From: RBRAM

To: SWR.Fargo

CC: RBram

Subj: Message for Jim Whitten

I am sending the letter of invitation that we sent out for our fly workshop. I thought it might be helpful to you in your preparations for the screwworm workshop.

ARS WORKSHOP ON
RURAL FLIES IN THE URBAN ENVIRONMENT
Beltsville Agricultural Research Center-West, Bldg. 005
November 9-10, 1988

AGENDA

November 9

R. A. Bram, Chairperson

8:15 - 8:30 a.m.	Opening and Introductions	R. R. Oltjen
8:30 - 9:30 a.m.	Definition of Problems	
	Feedlots	G. D. Thomas
	Poultry	J. A. Hogsette
	Dairy	R. W. Miller
	Legal Problems	D. K. Hayes
9:30 - 10:30 a.m.	Response to Discussants	All Participants
10:30 - 11:30 a.m.	Impact and Special Problems	All Participants
10:30 - 11:00 a.m.	BREAK	
11:00 - 12:00 p.m.	Conclusions	All Participants
12:00 - 1:30 p.m.	LUNCH	
R. W. Miller, Chairperson		
1:30 - 2:30 p.m.	ARS Research Activities	All Participants (5 minutes each)
2:30 - 3:15 p.m.	Overview of Research Outside ARS	D. K. Hayes
3:15 - 3:30 p.m.	BREAK	
3:30 - 4:00 p.m.	Panel Discussion on Research in Industry	R. S. Patterson (Discussion Leader) R. W. Miller C. J. Peterson
4:00 - 5:00 p.m.	Round Table: Problems Not Currently Being	G. D. Thomas (Discussion Leader)

November 10
D. K. Hayes, Chairperson

8:30 - 9:30 a.m.	Additional Research Needs New Approaches New Thrusts	All participants J. A. Miller (Discussion Leader)
9:30 - 11:00 a.m.	Prioritization	All participants E. T. Schmidtman (Discussion Leader)
11:00 - 12:00 p.m.	Future Plans Research Programs Work Assignments Interactions and Cooperative Activities Future Workshops, Symposia or Other Follow-up	All participants R. A. Bram (Discussion Leader)

September 1, 1988

SUBJECT: ARS Workshop on Rural Flies in the Urban Environment

TO: Distribution

FROM: R. A. Bram
National Program Leader
Insects Affecting Man & Animals and Parasitology

With the continuing encroachment of urbanization on agricultural areas, "fly problems" attributed to farm operations are receiving more and more attention. Although a number of ARS scientists devote at least a portion of their research effort to the biology and control of the principal fly species, attention has been directed toward animal productivity without much consideration to the rural/urban interface.

In order to address this problem, a workshop will be held on November 9-10, 1988, in Room 4, Building 005, at the Beltsville Agricultural Research Center. Objectives of the workshop will be to: (1) characterize and identify the impact of rural flies on the urban environment; (2) assess the ecology and ethology of fly species as related to urban settings; (3) review legislation and regulations as they apply to urban fly problems; (4) analyze the current research underway; and (5) define additional activities to be carried out with existing and new resources. An Agenda is attached.

Due to your expertise in this area of science and your current research assignment, it is my pleasure to invite you to participate in and contribute to the objectives of this important workshop. Please confirm your intention to participate on or before November 1, 1988, either by phone (FTS: 344-2771) or Telemail (RBram).

For those participants from out-of-town, I would recommend that you fly into the Baltimore-Washington International Airport. Limo service or rental cars are available on the lower level adjacent to the baggage claim area. Please feel free to make your own overnight accommodations. For convenience, I would recommend the Ramada Inn-Calverton, 4050 Powder Mill Road, Beltsville, Maryland (phone: (301) 572-7100).

303-229-5557
Assoc. AREA
Dir.

Workshop

Me - Chan Oct 4

Ralph " 5 1st 1/2 day

Julie

RL Mission
Le

Nutr Mission
"

Phys "

Ecol

Ben Fargo

Weslaco

Adm

CR remain

- Politically motivated
- Scientifically motivated

SWR.F

RELATIVE SPECIFICITY OF ATTRACTANTS FOR THE OLD WORLD

SCREWWORM FLY, *Chrysomya bezziana*

in NEW GUINEA

BAIT	SPECIFICITY RATIO (screwworm:all other)
Rotting liver	1 : 2600
Spent larval rearing medium	1 : 1000
Swormlure	1 : 140
Culture of bacteria from wounds	1 : 22

RELATIVE EFFICIENCY OF SCREWWORM TRAPPING SYSTEMS

for *Chrysomya bezziana*

in New Guinea

SYSTEM	EFFICIENCY
Swormlure trap (Australian)	1
Uninfested wound	6-7
Infested wound	13-14



United States
Department of
Agriculture

Agricultural
Research
Service

National
Program
Staff

Beltsville, Maryland
20705

Whitten

August 15, 1988

SUBJECT: ARS Screwworm Attractants Workshop

TO: Distribution

FROM: R. A. Bram *R.A. Bram*
National Program Leader
Insects Affecting Man & Animals and Parasitology

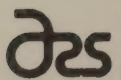
In order to assure that progress continues to be made in the scientific area of screwworm attraction, an ARS workshop on this subject will be held on October 4 and 5, 1988, at the Biosciences Research Laboratory, Fargo, North Dakota. Objectives of the workshop will be to: (1) review the present status of screwworm attractants research; (2) identify new areas of research which will produce technologies applicable to the screwworm eradication program; and (3) establish priorities and define requirements for the successful completion of this research.

Due to your expertise in this area of science, it is my pleasure to invite you to participate and contribute to the objectives of this important workshop. The preliminary workshop agenda is as follows:

- | | |
|----------------|---|
| October 4 a.m. | Present Status of Screwworm Attractants Research
Swormlure
Wound Attractants
Artificial Wound
Plant Attractants
Other (feeding, oviposition, etc.) |
| October 4 p.m. | Identify New Areas of Research and Establish Priorities |
| October 5 a.m. | Necessary Resources
Areas of Cooperation & Interaction
Workshop Summary |
| October 5 p.m. | Tour of the Biosciences Research Laboratory |

Please confirm your intentions to participate in this workshop no later than September 1, 1988, by contacting Dr. C. J. Whitten by phone (701-239-1265), by telemail (SWR.Fargo), or by mail (USDA, ARS, Biosciences Research Laboratory, P. O. Box 5674, University Station, Fargo, North Dakota 58105). He will, then, provide you with information on local arrangements and distribute the final agenda.

I look forward to seeing and working with you on October 4 and 5.



Agricultural
Research
Service

Distribution

2

cc:

R. R. Oltjen
T. J. Army
F. P. Horn
E. L. Corley
N. I. James
J. H. Wyss

Distribution:

C. J. Whitten, ARS
L. Hammack, ARS
R. D. Peterson, ARS
J. G. Pomonis, ARS
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R. L. Mangan, ARS
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H. C. Hofmann, APHIS
E. Gersabeck, APHIS
T. Ashley, APHIS
R. A. Flath, ARS
J. H. Tumlinson, ARS

PRIORITIES

1. Test effectiveness of swann-4 in comparison with wounded animals, leaven feeding stations, & dried blood in ^{the} 3 different ecological areas of Central America (Costa Rica) ^{Cooperative effort ARS & APNIS in T-B}
2. Define Host related phenomena (Long term project with probable interaction of Fango & Costa Rica with cooperation of T-B)
3. Wound Ecology - (Medium-term commitment - primary work ^{proposed} in Fango)
4. Improvement of swannlure system - dependent on results of First priority
5. Artificial wounds (Low input - sideline activity with field studies)
6. Plant attractants (Plant - scenerio ⁱⁿ adult relationships are important in population ecology studies ⁱⁿ C&A. - significant results could increase priority for attractancy relationship.

Workshop.

Objectives 1
2
3

Participants - See appendix 1

Results for obj 1 Review of press status

Results for obj 2
Needs

Results for obj 3

Notes
Status of Plant Attractants Research
ARS Attractants Workshop
Kelly Inn, Fargo, North Dakota
October 4-5, 1988

PETERSON

Distributed copy of research summary to participants.

Slides were shown of the flowering plants collected in Texas and tested in Fargo with an explanation of collection procedures.

Head space profiles of 7 plants from Texas have been made in cooperation with Pomomonis and Hakk (This work was inadvertently omitted from the summary handout).

Lack of results in laboratory rests with a lack of field observations and an understanding of just what attracts screwworms in nature.

Mackley suggested that the observations (Guillot and others in 1970s) in Texas of feeding and mating near flowers may have been an artifact of the large numbers of sterile flies.

Questions about the olfactometer arose, however, flies are just as "confined" in the Hammack or Adams models which apparently work. Would flies need more space to fly and respond to flowers than to wounds, blood, pheromones, and navel cords?

Ashley suggested a wind tunnel (the same recommendation was made at the last attractants meeting 10 years ago). Whether resources and space is made available this time around remains to be seen.

It is not certain that a wind tunnel is the most appropriate system for screening large numbers of samples and concurrent controls.

There may be a problem with using frozen material instead of fresh. If so, the initial work is better done in Costa Rica.

Peterson said that in his experience in the field and in the laboratory, flies are probably opportunistic in their foraging behavior. During the time the Acacia are in bloom, there is little else in the way of flower sources in the area.

MANGAN

Presented slides and data from and outdoor geodesic dome study in Tuxtla.

A large number of plants, both native and introduced, were grown in pots. Both male and females were introduced and their feeding behavior and diel periodicity determined. Their daily pattern of activities besides feeding was also observed.

There was no pattern to the plant families which flies appear interested in feeding upon. It appears to be a function of if they can probe the flower and reach the source, they will feed.

Extrafloral sources are no more attractive than flowers.

Both sexes exhibit a morning feeding activity, probably a function of early morning sun. Feeding activity declines in the afternoon.

Mangan was not able to demonstrate a strictly olfactory response to the flowers.

The lack of a uniform air flow to produce a defined plume inside the dome was cited as a possible reason no specific response was observed.

In other field observations, it was reported that flies appear attracted to certain pitcher plants.

PARKER

Observed that there are two types of plants involved ie. those that adults use as landing platforms, and those flowers that produce volatiles to which flies respond.

In the latter category, he reported that stepeliads produce odors that can out attract a dead animal.

Parker also feels that flower structure is the key to which flowers screwworms utilize. Visiting a flower does not mean that pollen will be picked up. Certain pollen types are more readily "stuck" to the fly.

His pollen identification studies have been from flies visiting wounds.

He uses a gel-staining technique where pollen from field collections can be removed from the fly and slides made in an efficient manner. In collaboration with Fargo, he will explore the possibility of using SEM photomicrographs in his pollen identification studies.

He has found that sterile males and females frequent the same flowers and that the Euphorbiaceae (probable Croton sp.) is the most common pollen encountered.

Croton blooms the year around in Costa Rica and he believes that the volatiles should be examined.

He made general comments on fly behavior and felt that screwworm and other fly sound may be attractive to others and a factor in the congregation phenomenon.

Bram summarized that from all that had been said, that it was unclear just what attracts screwworms to flowering plant and that testing the volatiles from live blossoms could be productive.

Tumlinson felt that you could very well lose what is really there in the way of volatiles when you start extracting. No alternatives were suggested.

ARS WORKSHOP ON ATTRACTANTS FOR SCREWORMS

Oct. 4-5, 1988

Fargo, ND

Tom R. Ashley

I. Status Reports

A. Swormlure

1. All components necessary otherwise a 50% reduction in effectiveness occurs.
2. #4 is 35-50% more attractive than #2.
3. All components of swormlure are necessary otherwise a 50% reduction in trap catches occurs.
4. The Australians are using an open trap with a roof shaped like an inverted V from which is suspended a flat bottom on which rests a flat insect covered with tack-trap. The swormlure is dispensed from the center of the bottom via a vial-wick system.
5. The Australians found a specificity ratio of 1:140 for swormlure as compared to a ratio of 1:20 for bacteria from the wound.
6. The WOT trap appears to be better in windy conditions where as the type of trap used by the Australians is better where winds are not strong.
7. Currently there are no efforts to improve the formulation of swormlure.

B. Wound attractants

1. The bacterium, Providencia rettgeri, was the most attractive to screwworm females of all of the bacteria tested.
2. A good ovipositional response was recorded for blood, but blood was a poor attractant.
3. When compared to a blood standard, naval cords or distillates of naval cords were less attractive to gravid females.
4. Naval wounds sprayed with antibiotics did not become infested with screwworm larvae.
5. There are four active fractions from steam distillates of blood and all four fractions are necessary for attraction. The number of compounds per fraction is unknown.

C. Artificial wounds

1. Gravid females come to wounds to oviposit. They may return daily to feed. Oviposition by these females occurs every three days.
2. A wound trap consisting of the rounded, reenforced end of a liter coke bottle into which several small funnels had been inserted could then be placed over the wound of an animal. Flies passing through the funnels into the trap could not escape.
3. Wounds were most attractive on the third day when larval crawl-out would have occurred on the fifth day.

4. Wounds remained very attractive after all screwworm larvae had been removed.
5. An artificial trap was described which consisted of an "L" shaped piece of PVC pipe. The top opening of the trap was a modified funnel behind which the attractant was placed. The lower portion of the trap held water which served as a solar heater.
6. The first landing of gravid females occurs close to the wound. They do not land randomly on the animals and then locate the wound.

D. Plant attractants

1. Acacia is one of the principal flowers fed upon by screwworms.
2. Screwworms may go to flowers in response to volatiles or perhaps the presence of other feeding insects. The shape and color of a flower may also influence the presence of screwworms.
3. Screwworms were found only on flowers in which the flies could insert their mouthparts.
4. Utilization of extrafloral nectaries by screwworm adults has not been observed.
5. Pollen collected in Costa Rica from adult flies is being identified to determine which species of plants are visited. There appear to be three or four principal plant species. Collections from flowers indicate that sterile males and females are visiting the same flowers as wild females.
6. The actual mechanism of attraction to flowers is not known.

E. Other attractants

1. In Costa Rica an adult feeding station containing liver attracts significantly more adults than a wounded animal.
2. No oviposition has occurred on this feeding station.
3. It appears that gravid females do not come to this feeding station.
4. Flies marked at the liver feeding station did not return to the station as frequently as flies marked at a wounded animal.

II. Priorities (arranged in order of importance)

- A. Determine if swarmlure is as effective as wounded animals, liver feeding station or dried blood in field tests. This is to be a cooperative effort between ARS and APHIS in Tuxtla.
- B. Define host related phenomena. This is a long term commitment to be carried out by ARS in Fargo and Costa Rica.
- C. Wound ecology. Medium term commitment to be done in conjunction with B above. To be done in Fargo utilizing a doctoral student on a cooperative agreement.
- D. Swarmlure - depends on the results of II-A. above.
- E. Artificial wounds - low priority, to be treated as a sideline activity.
- F. Plant attractants. Important from the standpoint of population ecology, but to be given low priority at this time.



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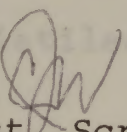
Northern Plains Area
Red River Valley Agricultural
Research Center
Biosciences Research
Laboratory

P.O. Box 5674
State University Station
Fargo, North Dakota
58105

September 9, 1988

SUBJECT: ARS Screwworm Attractants Workshop

TO: Participants

FROM: C.J. Whitten, 
Lead Scientist, Screwworm Research

Thank you for agreeing to participate in the Screwworm Attractants Workshop scheduled for Oct. 4-5. Enclosed are a copy of the agenda and a bibliography of publications pertinent to screwworm attractants, ecology, and behavior.

The agenda has been divided into 3 parts, each designed to address the objectives of the workshop:

1. To review the present status of screwworm attractants research,
2. To identify new areas of research which will produce technologies applicable to the screwworm eradication program,
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Even though you may not be identified on the agenda, but have pertinent data, please plan on presenting it. Projectors for 2x2 slides and overhead transparencies will be available. The meeting will be an informal workshop and your contribution will be welcomed.

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A block of rooms is being held at the Kelly Inn in Fargo (phone - (701) 282-2143) under the name "USDA". If you wish for me to make reservations for you, please tell me so when you give me your arrival time. A GOV will be available for visiting participants Oct. 3-6. If I know your arrival time, arrangements will be made to meet your flight.

Should other information be needed, please call me at (701) 239-1265 or leave a message at (701) 239-1204. I am looking forward to your participation in what should be a very productive workshop.

a. Larval effects
b. Bacterial effects
c. Host physiology

1 = priority

Depends on results of II prior

IDENTIFICATION OF NEEDED RESEARCH

ARS SCREWORM ATTRACTANTS WORKSHOP, 1988

4 A. SWORMLURE:

1. Analyze volatiles of SL-4 with time to improve formulation.
2. Test grouping of chemicals to improve effectiveness.
3. ~~Trap design & formulation~~ 3. Is swormlure as effective as wounded animals, liver feeding stations, or dried blood? (in 3 different ecological areas) in Central America

B. WOUND ATTRACTANTS

1. Field test of dried blood
2. Define host related phenomena
 - a. Attraction
 - 1) Develop bioassay.
 - 2) Sampling and collecting potential volatiles.
 - 3) Isolation and identification of chemicals responsible for response
 - 4) Synthesis and formulation of chemicals with attractant properties.
 - 5) Field evaluation of attractant chemicals.
 - b. Stimuli (whole animal concept)
 - 1) Biological
 - 2) Physical
 - 3) Chemical

- medium term commitment
3. Wound Ecology
 - a. Larval effects
 - b. Bacterial effects
 - c. Host physiology

⑤ C. ARTIFICIAL WOUNDS

(Low input
sideline
activity)

1. Ovipositional and feeding stimuli
 - a. Chemical aspects (to include fresh whole blood).
 - b. Physical aspects
 - c. Behavioral aspects (physiological controls).
2. Design concepts (mechanical aspects).

⑥ D. PLANT ATTRACTANTS

(important
in population
ecology)

1. Determine (identify) plants most frequently visited.
2. Identify stimuli responsible for response (ie. color, shape, odor, etc.).
3. Apply procedure used for wound attractant attraction components as applicable leading to field evaluation.

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Agricultural
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National
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Bassner
Beltsville, Maryland
20705

August 15, 1988

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National Program Leader
Insects Affecting Man & Animals and Parasitology

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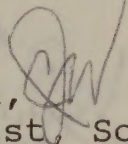
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UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
VETERINARY SERVICES
FEDERAL CENTER BUILDING
HYATTSVILLE, MARYLAND 20782

Whitten
120(II)

Subject: Observations on Screwworm
Oviposition Attractants

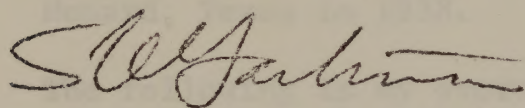
July 22, 1974

To: Dr. Wendell Snow
Station Leader
Entomology Research-ARS
Mission, Texas

Enclosed is a copy of a memorandum which Dr. Knipling wrote to Dr. Thacker at Fargo about observations on screwworm oviposition attractants. It is possible that you have already received a copy of this correspondence, but I am sending it along just in case you have not.

My personal observations, since being associated with the screwworm program, certainly parallel those which Dr. Knipling has written. I am sure that you will want to discuss this with your people and also with those of the Methods staff at Mission.

As you know, Dr. Williams and I both have expressed our strong interest in screwworm attractants both for adult flies and for oviposition response as well. I hope that we can get some breakthroughs in this area because I know it will help us a great deal in our field studies and for evaluation of what we are doing with our sterile fly releases.



S. C. Gartman
Chief Staff Veterinarian
Screwworm Eradication

Enc.

DN 707 52 10 10 80

UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

WASHINGTON, D.C. 20250

120 (11)

OFFICE OF ADMINISTRATOR

July 15, 1974

Subject: Observations on Screwworm Oviposition Attractants

To: Edward J. Thacker
Director, Metabolism and Radiation Research Laboratory
P.O. Box 5674
State University Station
Fargo, North Dakota 58102

From: E. F. Knipling
Consultant, ARS
Room 205, National Agricultural Library
Beltsville, Maryland 20705

Dr. Waldy Klassen requested that I relate certain observations on the attraction of screwworm flies to wounds or to larval media for purposes of oviposition. During the years that I worked on the screwworm, I conducted some research incidental to my major assigned projects to gain some information on the nature of attraction by flies to their hosts for oviposition. Not enough research was conducted on any aspect to justify publication before I was transferred to other projects and did not have the opportunity to do more work in this area. Also, a fire destroyed some data after I left Menard, Texas. However, I will summarize the observations made as I recall them. Some observations were made in an outdoor cage in Valdosta, Georgia, in 1936 and some were made in the laboratory at Menard, Texas in 1938.

The following is my overall assessment of the nature of oviposition responses by the screwworm fly and the potential role of artificial attractants for control and detection.

1. The female screwworm shows an intense oviposition response to wounds on warm-blooded animals and particularly for wounds infested with larvae. I would judge that average wounds containing larvae 3 days old or older would attract 5-10 times as many females for oviposition than the average uninfested wound.
2. As observed in field tests and published in the attached paper, uninfested wounds are more attractive for oviposition several days after they are made than during the first day.

*I believe this is true — but per operations certainly there
this characteristic*

SSG

3. While attractive substances coming from wounds produce the principal stimulus, gravid screwworm flies in large cages will fly around healthy host animals in apparent search for wounds. However, the animal itself without wounds is not a powerful attractant based on observations in a cage.

4. To my knowledge no one has established the relative degree of attractiveness of different kinds of hosts. It is my view that wounds on any of the farm livestock and larger wild animals are of the same magnitude of attractiveness. See reprint for data on sheep and goats.

5. A point that may have significance, however, is the high incidence of infestations in the navel of young animals. If there is such thing as a primary host for the screwworm, I would think that the young of animals could be regarded primary hosts. The navel cord and navel before they dry up are very highly attractive, which may offer a lead for the nature of the attractive components.

6. While an infested wound is highly attractive, artificial media in which larvae are feeding is also very highly attractive; thus, indicating that products developing in infested wounds or media are highly attractive.

7. However, the larvae per se apparently produce no ovipositional attraction. Media from which larvae have been removed is equally as attractive as media containing feeding larvae. Washed larvae exposed to flies possess no oviposition attractant. Also, uninfested wounds are also attractive even though much less so than infested wounds.

8. The temperature of the artificial media is a very important factor in the degree of attractiveness of the media for oviposition. Media in which larvae are developing when at room temperature has some attraction to gravid flies, but the response is many times as great if the media is warmed to about 105-110° F.

9. The temperature and the host animal are involved in increased attraction, but whether the animal per se contributes is not known. In a large outdoor cage (about 12' x 12' x 7') a 4-ounce piece of fresh beef tied to the neck of a sheep attracted about 10 times as many gravid females as a comparable 4-ounce piece of fresh beef placed on a shelf in the cage containing several hundred gravid females. However, the fresh meat, even when tied to a sheep was not highly attractive for oviposition. It would not be comparable

to a wound either uninfested or infested. Females are reluctant to oviposit on the pieces of meat. Unfortunately, older partially deteriorated meat was not tested.

10. Artificial media containing developing larvae or the media from which larvae have been removed, when heated to 105-110° F. and placed in 2-in. pill boxes with a 1/2-inch hole cut in the center of the top, and placed in cages containing perhaps 100 gravid flies will immediately cause an oviposition response. Dozens of females will immediately respond and soon begin ovipositing. The egg supply of most of the females (perhaps 75 percent or more) will be deposited on a single pill box containing heated media within a period of an hour.

11. It was not established if the heated media is more attractive than unheated media because the heat is a stimulus, or whether the heated media causes the liberation of a higher concentration of the attractant components. However, flies oviposit best when held at high temperatures. In routine egging, Dr. Bushland used to put flies in large vials with fresh meat and hold them at a high temperature (about 100° F.) during egging.

12. In my opinion, if the attractant components produced by an infested wound on animals or heated media in which larvae have fed could be duplicated as an "artificial wound"; this would represent a major breakthrough in screwworm research. Such attractant should be practical for screwworm suppression when populations are still low, and should provide a very sensitive method of detection and population assessment.

The efficiency of the attractant would no doubt be governed by the number of screwworms in an area. When populations are very low and natural infested wounds are few and widely scattered, a given number of "artificial wounds" should have a greater effect than the same number used when the natural population is high. As a hypothesis, one might assume that if the attraction to artificial wounds in an ecosystem exceeds attraction to natural infested and uninfested wounds by tenfold, one would expect 91 percent of gravid flies to exhaust their eggs on artificial wounds. If the attraction to artificial wounds is only equal to the attractant power of natural wounds, one would expect half the eggs to be deposited on the artificial wounds.

13. The release of sterile flies and the use of artificial wounds in an area should be highly complimentary in suppressive action.

One technique should potentiate the action of the other in a suppression program. This would be the ideal type of action desired when different suppression methods are combined.

14. The host animal may provide attractant factors that would increase the effectiveness of artificial oviposition attractants especially under field conditions. They may provide heat if needed for an artificial attractant or perhaps produce attractant components that potentiate responses to the attractant. For example, CO₂ may be involved as for blood sucking flies. This point should be kept in mind, but since the fact that warm media alone is highly attractive, this indicates that the animal is not a vital component.

15. Until the role that heat plays in attractiveness of wounds or infested media is known, it is my view that possible oviposition attractants should be tested when heated, perhaps using temperatures of the order of 110° F. or perhaps somewhat higher.

16. Even if an artificial wound attractant were not practical for control, it could provide a highly sensitive method of detecting where and how many screwworms were present and what percent of deposited eggs were sterile or fertile.

17. In my opinion research to identify and hopefully duplicate the natural oviposition stimulus produced in infested wounds and media should receive high priority. With modern advances in biochemical technology, the chances of doing so should be very good.

E. F. Knipling

E. F. Knipling
Consultant - ARS
Room 205, National
Agricultural Library
Beltsville, Maryland 20705

Enclosure

cc:

T. W. Edminster, ARS 50 12 00
W. Klassen, ARS
Donald Williams, ARS ✓
L. S. Henderson, ARS

AD-202
11-60

(5 PART)

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service, Pacific West Area
(AGENCY)

TRAVEL AUTHORIZATION

1. Authorization No.

9-C-5301-1029

2. Date

9/16/88

The person named below is authorized to travel and to incur necessary expenses of travel in accordance with provisions of applicable laws and regulations.

3. Name

ROBERT A. FLATH

4. Official Station

Albany, California

5. Title

Research Chemist

6. Travel to begin on or about

October 3, 1988

7. Travel to end on or about

October 6, 1988

8. Itinerary

From Albany, CA to Fargo, North Dakota and return.

9. Purpose of travel - Code 4

To participate in ARS Screwworm Attractants Workshop, to be held October 4-5 at the Biosciences Research Laboratory, USDA-ARS, Fargo, North Dakota, at the invitation of Dr. R. A. Bram, NPS.

10. Per diem allowance

Lodging NTE \$50/day; M&IE NTE \$25/day

11. Travel by privately-owned automobile is authorized; mileage at rates indicated below will be allowed: (Mileage allowances for change of station are shown in section 12.)

a. 225 Cents per mile plus ferry fares and bridge and tunnel tolls

b. _____ Cents per mile personal preference rate

12. In connection with change of station, the following will be allowed:

a. ☐ Transportation of immediate familyb. ☐ Transportation of household goods and personal effects

Mileage for use of privately-owned automobile for transportation of employee and members of his immediate family, as follows:

c. _____ Cents per mile when two or more persons travel together

d. _____ Cents per mile when one person travels alone

Funds to be contributed by:

C. J. Whitten

Biosciences Research Laboratory

University Station

PO BOX 5674

Fargo, North Dakota 58105 (telephone #701-239-1265)

Accounting Code:

901-5442-030

The travel and transportation authorized above are in the interest, and to the advantage, of the Government, and the change of station, if any, is not made primarily for the convenience or benefit of the employee or at his request.

Name and title of authorizing official

Signature

WILLIAM G. CHACE, JR., AAD

Daniel A. McFadden

September 20, 1988

Robert A. Flath

Fargo, ND and return
October 3 through 6, 1988

Reservations through Miller Gove Travel Assoc.
Rick -- 652-3043

October 3 (Mon.)

LV Oakland (UA 720)	2:30pm
AR Denver	5:44pm
LV Denver (UA 662)	6:35pm
AR Fargo	9:18pm

October 4-5 (Tues., Wed.)

Workshop

October 6 (Thurs.)

LV Fargo (UA 981)	7:00am
AR Denver	7:46am
LV Denver (UA 389)	8:40am
AR Oakland	10:04am

Fare quoted = \$690.00



United States
Department of
Agriculture

Agricultural
Research
Service

Pacific West Area

800 Buchanan Street
Albany, California
94710

September 20, 1988

Dr. C. J. Whitten
Biosciences Research Lab
P.O. Box 5674
University Station
Fargo, ND 58105

Dear Jim:

For your information, I am enclosing copies of my flight schedule and my Travel Authorization. I hope you or Leslie are not inconvenienced too much by my 9:18 p.m. arrival in Fargo.

I have made no motel reservations as yet. Would you mind making them for me, at the motel where the workshop is to be held? Otherwise, I can make the arrangements myself, once your information packet arrives.

I am looking forward to seeing all of you again; I hope I can contribute something to the workshop discussions as well.

Sincerely,

ROBERT A. FLATH
Research Chemist
Plant Protection Research Unit

Enclosures

Tom Ashley

1v Friday

3rd

7:52 pm

NW 224

Visa 4443-0401-0320-

2/90

-8743

Thomas^R Ashley

Tumlinson

Bram

Flath

Mackley

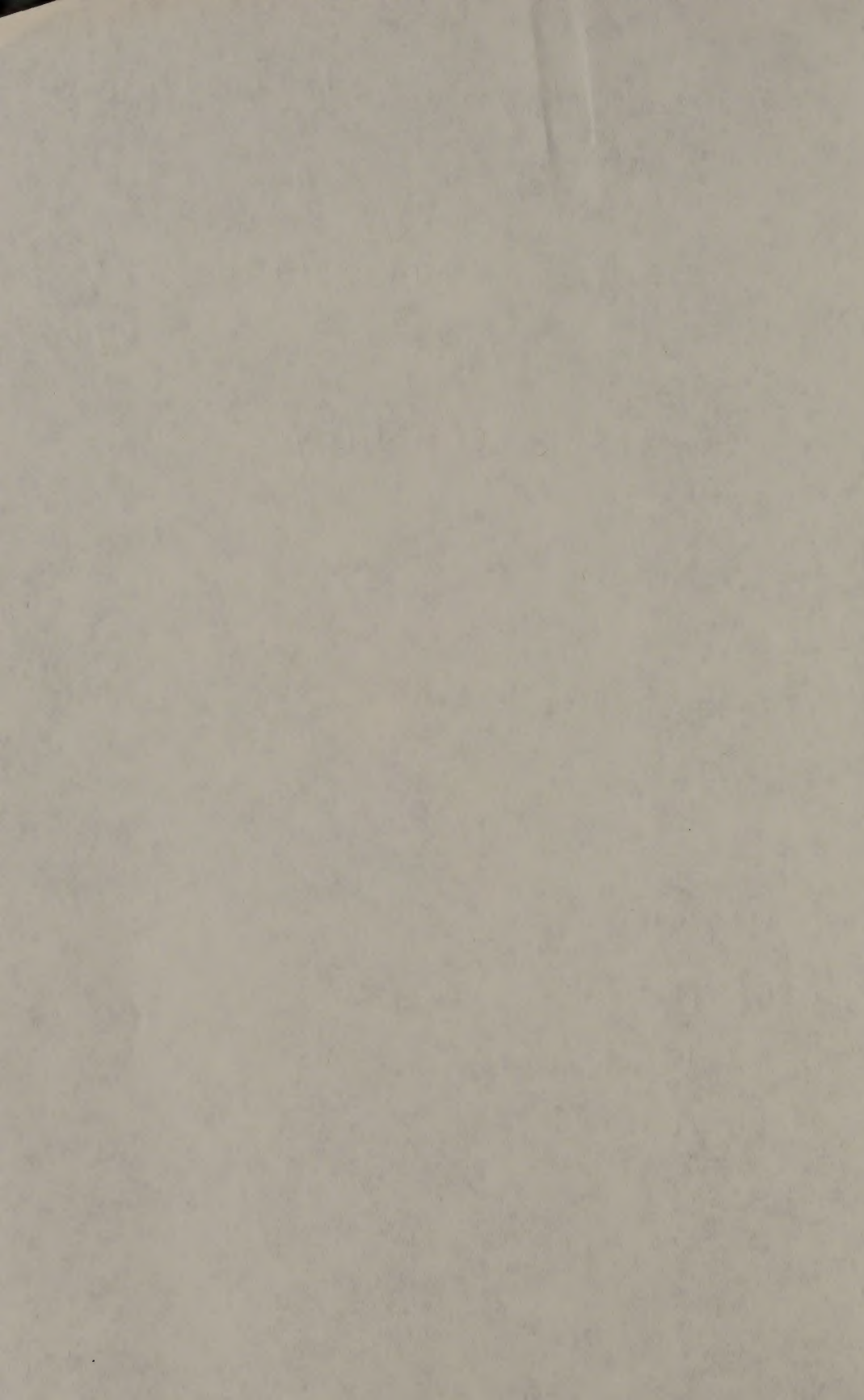
Freese

Mangan

Parker

Gersabeck

Hofmann



Tumlinson

Oct 2 7:52

NW 545

Oct 5 2:25

W 3:30

Single

Sept. 22, 1988

Arrival and Departure Schedule for USDA Workshop Participants

Name	Origin	Arrival Date	Departure Date
ASHLEY, T	Florida	10/3	10/7
BRAM, R.	Maryland	10/3	10/6
FLATH, R.	California	10/3	
FRIESE, D.	Mexico	10/3	
GERZABECK, E.	Mexico	10/3	
HOFMANN, C.	Mexico	10/3	
MACKLEY, J.	Mexico	10/3	
MANGAN, R.	Mexico	10/3	
PARKER, F.	Costa Rica	10/3	
TUMLINSON, J.	Florida	10/3	10/5

Sept. 22, 1988

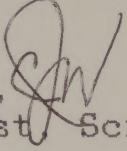
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BRAM, R.	Maryland	10/3	10/6
FLATH, R.	California	10/3	
FRIESE, D.	Mexico	10/3	
GERZABECK, E.	Mexico	10/3	
HOFMANN, C.	Mexico	10/3	
MACKLEY, J.	Mexico	10/3	
MANGAN, R.	Mexico	10/3	
PARKER, F.	Costa Rica	10/3	
TUMLINSON, J.	Florida	10/3	10/5

September 22, 1988

SUBJECT: ARS Screwworm Attractants Workshop

TO: Patsy Evenson
Heldur Haak
Renee McClean
Phil Meyer

FROM: C.J. Whitten, 
Lead Scientist, Screwworm Research

Attached is material pertinent to a screwworm attractants workshop scheduled for Oct. 4-5. Because of your involvement with certain aspects of the research, you are invited to attend the session on Oct. 4. The presentations and discussion could be helpful in providing a more complete perspective of our attractants research as well as the interaction between research and the eradication program.

I have discussed your attendance with your supervisors and they are in concurrence.

Please let me know if you plan to attend.

cc:

L. Hammack
R. Peterson
G. Pomonis
G. Gassner

~~Turner~~ ~~son~~

~~BRAM~~

~~Flath~~

Tuxtla - Se. Res.

Mangan - P.O. Box 3149 Laredo 78041
Am Emb PSC 496

Parlcer - APO Miami 34020

Hofmann - P.O. Box 3087 Laredo

Mackley - P.O. Box 3087

Berzbeck " "

Ashley 1700 SW 23rd DR P.D. 14565 32604

Horn USDA-ARS-SPA 1812 Welsh St, Suite 130
E.S. 77840

Novy - P.O. Box 3087 Laredo

Sept. 29, 1988

Arrival and Departure Schedule for USDA Workshop Participants

Name	Origin	Arrival Date	FLT/TIME	Departure Date
ASHLEY, T	Florida	10/3	NW545 7:52pm	10/7
BRAM, R.	Maryland	10/3	NW224 3:13pm	10/6
FLATH, R.	California	10/3	UA662 9:18pm	10/6
FRIESE, D.	Mexico	10/3	UA387 8:44pm	10/6
GERZABECK, E.	Mexico	10/3	UA387 8:44pm	10/6
HOFMANN, C.	Mexico	10/3	UA662 9:18pm	10/5
MACKLEY, J.	Mexico	10/3	NW545 7:52pm	10/6
MANGAN, R.	Mexico	10/3	UA387 8:44pm	10/6
PARKER, F.	Costa Rica	10/3	UA662 9:18pm	Open
TUMLINSON, J.	Florida	10/3	NW545 7:52pm	10/5

ARS WORKSHOP ON ATTRACTANTS FOR SCREWORMS

O'Leary Room, Kelly Inn
Fargo, ND
October, 4-5, 1988

AGENDA

OCTOBER 4 - C.J. Whitten , Chairperson

8:30	Opening and Introductions	
	Status Reports	
8:45	Status Report on Swormlure	Mackley/Whitten
9:15	Discussion	Participants
9:30	Status Report on Wound Attractants	Hammack/Pomonis/Flath
10:00	Discussion	Participants
10:15	BREAK	
10:30	Status Report on Artificial Wounds	Mangan/Parker
11:00	Discussion	Participants
11:15	Status Report on Plant Attractants	Peterson/Parker/ Mangan
11:45	Discussion	Participants
12:00	LUNCH - Kelly Inn	
1:30	Status Report on Other Attractants (Feeding, Oviposition, etc.)	Peterson/Hammack
2:00	Discussion	Participants
	Identification of Needed Research	
2:15	Swormlure	Participants
2:45	Wound Attractants	Participants
3:15	BREAK	
3:30	Artificial Wounds	Participants
4:00	Plant Attractants	Participants
4:30	Other Attractants	Participants
	DINNER - Trader & Trapper, Moorhead	Participants

October 5 - Ralph Bram, Chairperson

Priorities and Resources

8:30 am	Establish Research Priorities	Participants
9:30	Determination of Resources	Participants
10:00	BREAK	
10:15	Areas of Cooperation and Interaction	Bram
10:45	Workshop Summary	Bram
	LUNCH	

Remainder of available time for participants tour of screwworm lab,
Biosciences Research Lab and/or visitation with scientists.

IDENTIFICATION OF NEEDED RESEARCH
ARS SCREWORM ATTRACTANTS WORKSHOP, 1988

A. SWORMLURE:

1. Analyze volatiles of SL-4 with time to improve formulation.
2. Test grouping of chemicals to improve effectiveness.
3. Is swormlure as effective as wounded animals, liver feeding stations, or dried blood?

B. WOUND ATTRACTANTS

1. Field test of dried blood
2. Define host related phenomena
 - a. Attraction
 - 1) Develop bioassay.
 - 2) Sampling and collecting potential volatiles.
 - 3) Isolation and identification of chemicals responsible for response
 - 4) Synthesis and formulation of chemicals with attractant properties.
 - 5) Field evaluation of attractant chemicals.
 - b. Stimuli
 - 1) Biological
 - 2) Physical
 - 3) Chemical

C. ARTIFICIAL WOUNDS

1. Ovipositional and feeding stimuli
 - a. Chemical aspects (to include fresh whole blood).
 - b. Physical aspects
 - c. Behavioral aspects (physiological controls).
2. Design concepts (mechanical aspects).

D. PLANT ATTRACTANTS

1. Determine (identify) plants most frequently visited.
2. Identify stimuli responsible for response (ie. color, shape, odor, etc.).
3. Apply procedure used for wound attractant attraction components as applicable leading to field evaluation.

Plant and Feeding Attractant Research on the Screwworm,

Cochliomyia hominivorax (Coquerel)

1988

Richard D. Peterson II

INTRODUCTION

Research on plant and screwworm, Cochliomyia hominivorax (Coquerel) interaction has been conducted sporadically for over 15 years. The reason for this effort seemed justified based on early work in south Texas that indicated that some screwworms rest, feed, and/or mate in the vicinity of flowering plants. With the development of swormlure in the mid 1970s, research into the role played by plants in screwworm biology dwindled. With the recent loss of confidence in the use of swormlure in the tropics, interest in alternative attractants was again encouraged. The following is an overview of what is known of the interaction between plants and screwworms and a brief review of recent research.

REVIEW

Adult screwworm feeding on flowers has been known for many years (Laake et al 1936). Field studies have revealed that sexually active male screwworms utilize aggregation sites where they wait for receptive females. It was found that certain flowering shrubs of the Acacia species were particularly attractive to both sexes (Guillot et al 1978). Krafsur (1978) made similar observations on nonflowering vegetation. Recently,

Broce and Ideker (1978) described that adults were trapped while feeding in oleander (Nerium oleander L.) flowers. Mackley and Long (1983) reported on the screwworm feeding, mating, and resting behavior on various flowering trees and shrubs, including Acacia, in south Texas. In an effort to clarify the sugar requirements of screwworms, Peterson et al (1987) reported on sugar feeding and its effect of longevity and oocyte maturation. In a related study, Peterson (1982) reported on the effect of trap color on field collections of screwworms.

In related species, Cuthbertson (1935) observed males of Chrysomia bezziana Villeneuve feeding on flower nectar, and Webber (1957) reported that the nectar of Eucalyptus was a source of carbohydrate for Lucilia cuprina (Wied.). Insect, and perhaps screwworm, feeding on carbohydrate sources is not limited to flowering plants but includes a wide range of extrafloral sources (Rogers 1985).

Clearly, flowering trees and shrubs serve screwworms in a variety of ways ie. 1.) as locations for waiting stations near which mating may occur, 2.) flower and extra floral sources provide carbohydrates for physiological development and maintenance, and 3.) as places to rest and escape environmental stress. Do flies respond to flowers to fulfill a need for carbohydrates and if so which flowers provide the complex needed by the fly. Is feeding and mating behavior linked or do flies respond to one need and not the other. Do flies respond to floral chemical cues and flower color, or are they opportunistic and respond to whatever is in bloom. Are males responding to the presence of other males in the area and do the waiting stations become fouled with chemical compounds that

other males (or females?) respond too. The visual and chemical stimuli responsible for these behaviors is probably of a multicomponent nature and requires a multidirectional research approach.

PLANT ATTRACTANTS

As a follow up to previous studies, flowers from Acacia berlandieri Benth., A. rigidula Benth. and A. farnesiana (L.) Willd. were selected for further study in the laboratory. Of these, A. farnesiana had been extensively studied for its chemical properties because of its use in the perfume industry (Demole 1969). To ascertain the volatile components of the 3 species, the flowers were analysed and compared by capillary gas chromatography and mass spectrometry and a total of 114 compounds were identified (Flath et al 1983). Certain fractions of these volatile extracts were bioassayed for their ability to illicit a response from adult screwworms (Mackley and Holt 1978). Results from their study and of others (Hammack, unpublished data) indicated that screwworms were attracted to A. rigidula and A. berlandieri.

Our first objective was to devise a bioassay chamber and evaluate the response of flies to fresh (frozen) blossoms of Acacia and other flowering plants. In 1986 and 1987, fresh flower material was collected near Mission, TX, stored on dry ice, and returned to the laboratory in Fargo. Species collected besides Acacia were, Prosopis glandulosa (Torr.) Cockerell, Mimosa strigillosa T. & G., Pithecellobium flexicaule (Benth.) Coult., and two species of Helianthus. Specimens were identified with the assistance of Dr. R. I. Lonard, Dept. of Biology, Pan American Univ., Edinburg, TX. Dry mounts were made in cooperation with Dr. W. T.

Barker, Botany Dept., North Dakota State Univ., and serve as our reference collection.

The methodology and desirability of various bioassay chambers have been reviewed by Kennedy (1977). Olfactometer designs have been as varied as the insects for which they were designed (Gouck 1972, Bay and Pitts 1976). Early workers measured screwworm response to test odors emanating from dental wicks in outdoor cages (Fletcher and Turner 1973). Adams et al (1979) in their work with screwworm response to carrion odors used a modified 4-port olfactometer that was originally developed for sex attraction studies of the stable fly, Stomoxys calcitrans (L.). The same model was used by Hammack and Holt (1983) to measure screwworm response to wounds, wound fluid and a standard blood attractant. Holt et al (1979) used a modified Y-tube in measuring attraction to simulated bovine wounds. In the preliminary analysis of extracted Acacia volatiles, Mackley and Holt (1978) used a Y-tube designed after Bay and Pitts (1972).

Our initial observations on fly response to blossoms were made in a simple 2-choice plexiglas box. The box (11 x 7 1/2 x 24") was accessed on both ends thru sleeve openings. A sliding partition permitted putting test material on one side of the partition and the test flies in the other. A crude airflow apparatus was rigged to allow passing air over the test sample and past the test flies. It was decided, however, that a bioassay chamber with more control over the many variables was needed. The bioassay design decided upon was a modification of the Y-tube described by Adams et al (1984). Each of 3 olfactometers was constructed of 1/4 " (inside diameter) clear plexiglas with each arm (spread 90°) and the

stem of the Y made 15" long. A screen cone with an entrance hole was placed near the upper end of each arm to trap responding adults as they moved up the stem and into the arms. The the open end bottom of the Y-tube stem sits over a hole in a box which houses a thru-flow vacuum motor. The motor pulls air through the end of each Y-arm, over the substance (blossom or extract) being tested and down the Y-stem past the test insects. Improvements in the existing design include passing incoming air through activated charcoal then thru a Gilmont flowmeter each in line with a needle valve used to equalize the air flow entering each arm of the Y. Air speed is then measured with an Airflow anemometer in the stem at the point where the adults are introduced. Adjusting the airflow to the desired velocity is accomplished with a rheostat which controls the vacuum motor. Air which is passed thru the system is exhausted outside the testing room. The 3 olfactometers are housed side-by-side in separate white painted chambers (36 x 31 x 31"). The front of each chamber is covered by a white drop cloth which can be raised to allow access to the olfactometer before and after a test. Alternately, black cloth can be hung from the inside box walls creating a darkened chamber. Above each chamber is a set of fluorescent lights (2 x 24") on either side and 3 incandescent lights in the center. The intensity of the incandescents can be controlled with a dimmer switch. This allowed for a range of light intensities of different wavelengths, although still below the range and intensities of natural light. The testing room environment is controlled with two humidifiers, a dehumidifier, airconditioner and heating system. Temperature and relative humidity is monitored with a

Belfort hygrothermograph and a wall mounted Cole-Parmer digital unit.

Initial studies were conducted to determine, 1.) if there was a bias in either of the Y-arms, 2.) any directional bias as to Y-arm position, 3.) optimum age of males and females most likely to respond to the light source, and 4.) the strain of screwworm most likely to respond positively to the light source. Based on conversations with T. Adams and L. Hammack, it was decided to begin testing adults exposed to full light (incandescent and fluorscent), an air speed of 0.75 m/sec., 10 fed (up until the time of testing) flies/olfactometer (ie. 30 total adults) and a 15 min. exposure time.

Male and female flies 1-12 day old were tested ie. 3 reps of 10 adults each sex and age. The ages selected were arbitrary, however, as it was felt that older flies may not respond to a mating/feeding attractant as well as younger flies, and that older caged flies suffer wing damage making flight up a Y-tube difficult. Strain selection was at random for this phase of the study. It was determined that no inherent bias existed in either Y-arm (right or left) or in position. Age of flies responding indicated 2 and 6 day old males and females responded more positively than other ages to the light source.

It was decided that when testing materials in the olfactometer, the sample would be placed in the right arm of units 1 and 3, with unit 2 serving as a control to monitor any aberration on test day. Percent attrantancy was measured by the following:

$$\% \text{ Attracted} = \frac{\text{Treated} - \text{Control}}{\text{Total No. Tested}} \times 100$$

Any response greater than 50% attracted was considered worthy of a follow up investigation. Tests run concurrently in the 4-choice olfactometer of Hammack et al using the same strain and age of flies and a standard blood attractant showed similiar results but less attractancy in the Y-tube. In an effort to improve upon the number of flies responding, a series of tests were conducted to determine which of variables would maximize response ie black/white test chambers, incandescent/flourescent light combinations, air speed, and temperature/humidity, that which we could control. Thawed flowers of A. berlandieri, P. glandulosa, P. flexicaule, and M. strigillosa have been tested in the 2-choice box and the Y-tube. In addition, we have tested 25 and 50% honey, and 50% corn syrup solutions. To date we have not been able to show a significant response to A. berlandieri as had been previously reported. Even with control over most variables, which we incorporated into the original design, it is possible further modifcaiton will be needed. There are a number of differences in how we hold and test our flies compared to those used in the 4-port olfactometer of Hammack et al. The main difference is that our flies are held and tested in rooms that were previously larval rearing areas. The holding room more recently was used for insecticide testing. This aside, we feel that, at this time, fly attraction to flowering plants is more complex than can be measured in our olfactometer.

As an outgrowth of this, we decided to examine in the 2-choice box the attractant or repellent qualities of four compounds present in the Acacia. Methyl salicylate (M), p-anisaldehyde (P), geraniol (G), and eugenol (E) were studied. M, P and G are all represented in A. farnesiana, the least

attractive Acacia from earlier work. Eugenol is a major constituent of A. berlandieri and A. rigidula, flowers reported to be most attractive. The material was dispensed on cotton wick either from the bottle or as a 1% (70% ethanol) solution. The compounds were tested singly or as mixtures. We were unable to demonstrate any significant attractancy or repellency to the compounds.

We plan to test in the 2-choice and Y-tube olfactometer certain of the Acacia steam distillates as prepared by Flath (1983). The hexane fractions will also be compared in the 2-choice box. Any testing of these fraction in the Y-tube would require a glass model. Until we have more confidence in the basic Y-tube design and the conditions during testing, these test will be postponed.

In support of the laboratory in Costa Rica and their interest in pollen identification from field collected screwworms, we have begun a working relationship with Dr. S. M. Newman, Biosciences electron microscope facility. We have developed a simple technique to collect, dry, and mount pollen grains for making SEM photomicrographs. To date we have photographed pollen from A. berlandieri, A. rigidula, Acacia schaffneri (S. Wats.) Herman, P. flexicaule, P. glandulosa, M. strigillosa, and a species of Helianthus.

FEEDING ATTRACTANTS

As an extension of studies by Peterson et al (1987) we began to look at the response of flies to different fruit pulp in the olfactometer and their effect on survival. Banana (the only tropical fruit readily available in Fargo) and unadulterated processed applesauce were tested.

The banana was allowed to overripen, was mashed and put into food cups. The applesauce was used straight from the jar. Neither showed significant attractancy or repellency in the olfactometer.

In caged survival studies, however, a difference was readily apparent. When fed banana, with food cups changed daily, male and female screwworms did not survive beyond 7 days (LT_{50}) while flies fed corn syrup lived at least twice as long, 15-24 days. In another study flies were offered both corn syrup and banana in separate food cups. The results were similar. It appears that banana is an attractive food source, even in the presence of corn syrup, but does not provide sufficient nutrition for survival.

Flies fed applesauce, however, lived as long or longer than control flies fed corn syrup. Corn syrup fed males and females survived 12-14, and 18 days (LT_{50}), respectively. Applesauce fed males and females survived 17-18 and 29 days (LT_{50}), respectively. Applesauce fed females matured their eggs at the same rate as those fed corn syrup. Applesauce is a suitable, although an expensive food source. This prompted us to examine 3 of the components of apple aroma. The three chosen for study were amyl butyrate, amyl acetate, and amyl valerate. All three were tested singly and as a mixture and compared in the 2-choice box. The material was dispensed on cotton wicks either straight from the bottle or as 1% (70% ethanol) solutions. No significant attraction could be demonstrated by either sex or age of 009 strain. Perhaps a more recently colonized strain would respond differently.

Further sugar preference studies are planned. We have been able to incorporate different sugar solutions with carrageenan gel. This produces gel similiar in consistency to the corn syrup gel routinely used for our stock colonies. The sugars, sucrose, fructose, maltose, and glucose will be evaluated singly and in combination to determine their effect on survival and ovarian maturation. The cups can pe prepared, then weighed before and after exposure. The amount of weight lost compared to controls unexposed to flies is measurable. We hope to be able to determine the preference for individual and combination of sugars selected by different aged males and female screwworms.

There is also a need to be able to analyse the gut contents of flies in nature. A considerable research effort on this was made by Dr. R. J. Brenner, ARS, during his time in Mexico. We are unsure of the exact reasons why, but there were difficulties in the analysis with certain factors masking the results. This is an area that scientists in Costa Rica and Fargo might persue together.

MULTIDIRECTIONAL APPROACH

The possibility exists that screwworms are attracted to flowering plants and waiting stations not because of flower volatiles, but because other screwworms are in the vicinity. To clarify this, we have begun a series of tests to evaluate the effect of "fouling" on fly response to their own sex, the opposite sex, and the presence of flowers. These studies are being conducted in the 2-choice box. Ten flies are allowed 6 hr contact of a 9 cm disc of filter paper. This paper is then introduced into the box with test flies of the same or different sex, with or without

flowers present. Counts are made of flies resting, making contact, or otherwise responding to the test material(s) during two consecutive 5 min observation periods. This is a new study, hence we have no results to report.

REFERENCES CITED

- Adams, T. S., Holt, G. G. and G. J. Blomquist. 1984. Endocrine control of pheromone biosynthesis and mating behavior in the housefly, Musca domestica. In Advances in Invertebrate Reproduction 3, ed. W. Engels. Elsevier Sci. Publ.: Amsterdam. pp. 441-457.
- Adams, T. S., G. G. Holt and W. D. Sundet. 1979. Physical and physiological effects on the response of female screwworms, Cochliomyia hominivorax (Diptera: Calliphoridae), to carrion odors in an olfactometer. J. Med. Entomol. 15 (2): 124-131.
- Bay, D. E. and C. W. Pitts. 1976. Olfactory responses of face flies, Musca autumnalis, to bovine feces. Ann. Entomol. Soc. 69 (5): 933-936.
- Broce, A. B. and J. Ideker. 1978. Oleander flowers as insect traps. Ann. Entomol. Soc. 71 (4): 628-629.
- Cuthbertson, A. 1935. The life history of the screw-worm fly. Rhod. Agric. J. 31: 256-258.
- Demole, E., P. Enggist and M. Stoll. 1969. Sur les constituants odorants de l'essence absolue de Cassis (Acacia farnesiana Willd.). Helv. Chim. Acta 52 (1): 24-32.
- Flath, R. A., T. R. Mon, G. Lorenz, C. J. Whitten and J. W. Mackley. 1983. Volatile components of Acacia sp. blossoms. J. Agric Food Chem. 31 (6): 1168-1170.
- Fletcher, L. W. and J. P. Turner. 1973. Response of female screwworm to a selected odor. Ann. Entomol. Soc. Amer. 1: 84-85.

- Gouck, H. K. 1972. Host preferences of various strains of Aedes aegypti and A. simpsoni as determined by an olfactometer. Bull. Wld. Hlth. Org. 47: 680-683.
- Guillot, F. S., H. E. Brown and A. B. Broce. 1978. Behavior of sexually active male screwworm flies. Ann. Entomol. Soc. 71 (2): 199-201.
- Hammack, L. 1984. Relationship of larval rearing variables to fly attraction and oviposition responses in the screwworm, Cochliomyia hominivorax (Diptera: Calliphoridae). J. Med. Entomol. 21 (3): 351-356.
- Hammack, L. and G. G. Holt. 1983. Response of gravid screwworm flies, Cochliomyia hominivorax, to whole wounds, wound fluid, and a standard blood attractant in olfactometer tests. J. Chem. Ecol. 9 (7): 913-922.
- Holt, G. G., T. S. Adams and W. D. Sundet. 1979. Attraction and ovipositional response of screwworms, Cochliomyia hominivorax (Diptera: Calliphoridae), to simulated bovine wounds. J. Med. Entomol. 16 (3): 248-253.
- Kennedy, J. S. 1977. Behaviorally discriminating assays of attractants and repellents. In Chemical Control of Insect Behavior, eds. H. H. Shorey and J. J. McKelvey, Jr. John Wiley & Sons, New York.
- Krafsur, E. S. 1978. Aggragation of male screwworm flies, Cochliomyia hominivorax (Coquerel) in south Texas (Diptera: Calliphoridae) Proc. Entomol. Soc. Wash. 80: 164-170.

- Laake, E. W., E. C. Cushing and H. E. Parish. 1936. Biology of the primary screwworm fly, Cochliomyia americana, and a comparison of its stages of those of C. macellaria. U. S. Dept. Agric. Tech. Bull. 500. 24 pp.
- Mackley, J. and J. Holt. 1978. Analysis of extracted flower volatiles. Third Quarterly Report, Screwworm Research Laboratory, Mission, TX. p. 120-125.
- Mackley, J. W. and G. L. Long. 1983. Behavior of sterile adult screwworms (Diptera: Calliphoridae) on flowering trees and shrubs. Ann. Entomol. Soc. 76 (5): 839-843.
- Peterson, R. D. II. 1982. Influence of trap color and height above ground on capture of screwworms. Southwest Entomol. 7 (4): 240-243.
- Peterson, R. D. II, J. W. Mackley, and A. O. Candido. 1987. Sugar feeding by adult screwworms (Diptera: Calliphoridae) and its effect on longevity and oocyte maturation. Ann. Entomol. Soc. Amer. 80 (2): 130-135.
- Rogers, C. E. 1985, Extrafloral nectar: Entomolgical implications. Bull. Entomol. Soc. Amer. 4: 15-20.
- Webber, L. G. 1957. Utilization and digestion of carbohydrates by the Australian sheep blowfly, Lucila cuprina. Aust. J. Zool. 5: 164-172.

1916 Bishop, F.C.
Flytraps and their operation

USDA Forests Bull. 734 14 pp

Description and use of "Bishop" trap used in trapping screwworms until the advent of the "seed oriented trap"

A Bibliography of Screwworm Attractants,

Ecology, & Behavior Research

- 1943 Hightower, B.B.
Local Distribution of Released Laboratory-Raised Screwworm Flies in Relation to Water Sources
J. Econ. Entomol. 36: 798-802
Two series of field releases of marked laboratory-reared screwworm flies *Cochliomyia hominivorax* were carried out in southwest and central Texas to determine the local distribution of the flies in relation to stock. In the first series, flies released on liver-baited trap catches, flies released in a semi-arid brushy area with no running streams tended to disperse in all directions. Flies released in an area crossed by running streams continued to disperse beyond a stream 0.5 to 1 mile from the release point to points on a second stream up to 1 mile beyond the first stream. Evidence is presented that the flies were channelled to some traps by terrain features. Local concentrations of flies on the stream nearest the release point persisted for 3 to 4 days. Peak catches of flies were noted on the third day following release. During the hot dry weather of late summer flies could not be detected along either stream.

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ARS Screwworm Attractants Workshop

- 1943 Hightower, B.B.
Nocturnal Resting Places of the Screwworm Fly

J. Econ. Entomol. 36: 498-500
Large numbers of screwworm flies (*Cochliomyia hominivorax* (Coquillett)) were marked with tracing powder fluorescent under ultraviolet light and released in the field in the afternoons and recovered during subsequent searches on following nights. Flies tended to congregate at streams and ponds of livestock, but recoveries from even the most favored locations were not large. More than 90% of recovered flies were found resting on small leafless twigs in low-canopy trees.

1916 Bishopp, F.C.
Flytraps and their operation

USDA Farmers' Bull. 734 14 pp

Description and use of "Bishopp" trap used in trapping screwworms until the advent of the "wind oriented trap"

1963 Hightower, B.G. and Alley, D.A.

Local Distribution of Released Laboratory-Reared Screwworm Flies in Relation to Water Sources

J. Econ. Entomol. 56: 798-802

Two series of field release of marked laboratory-reared screwworm flies, *Cochliomyia hominivorax* (Coquerel), were carried out in southwest and central Texas to determine the local distribution of the flies in relation to stock ponds and streams. According to samples based on liver-baited trap catches, flies released in a semi-arid brushy area with no running streams tended to congregate around stock ponds. Flies released in an area crossed by running streams continued to disperse beyond a stream 0.8 to 1 mile from the release point to points on a second stream up to 1 mile beyond the first stream. Evidence is presented that the flies were channeled to some traps by terrain features. Local concentrations of flies on the stream nearest the release point persisted for 3 to 4 days. Peak catches of flies were noted on the third day following release. During the hot dry weather of late summer flies could not be detected along either stream.

1963 Hightower, B.G.

Nocturnal Resting Places of the Screwworm Fly

J. Econ. Entomol. 56: 498-500

Large numbers of screwworm flies (*Cochliomyia hominivorax* (Coquerel)) marked with tracing powder fluorescent under ultraviolet light were released in the field in the afternoons and recovered during systematic searches on following nights. Flies tended to congregate at streams and pens of livestock, but recoveries from even the most favored locations were not large. More than 90% of recovered flies were found resting on small leafless twigs in low-canopy trees.

1964 Crystal, M.M.

Observations on the Role of Light, Temperature, Age, and Sex in the Response of Screwworm Flies to Attractants

J. Econ. Entomol. 57: 324-325

Observations made while screening candidate attractants for the screwworm fly, *Cochliomyia hominivorax* (Coquerel), revealed that light was an environmental factor affecting fly response. In unbaited traps about 25 times more flies were captured in light than in darkness. At temperatures ranging from 86-113 F, 3 times as many flies were captured as at those from 67-80. Oviposition took place in temperatures ranging from 86-113; the greatest number of egg masses were deposited at 104- + 6. In baited traps very few 1- to 2-day old flies were captured among 1- to 7-day-old flies tested; the greatest attraction was obtained when the flies were 3-4 days old. Among flies 6-8 days old tested for their attraction to liver and blood, about 5 times more females than males were trapped.

1969 Hightower, B.G. and Adams, A.L.

Dispersal and Local Distribution of Laboratory-Reared Sterile Screwworm Flies Released in Winter

J. Econ. Entomol. 62: 259-261

In using the sterile-male technique to eradicate the screwworm from the southwestern U.S., emphasis has been placed on eliminating infestations in areas where the species could overwinter. Since the critical thermal average for survival for any life stage of the screwworm is 10 degrees C for 3 successive months, infestations occurred in the large area in Texas that is normally south of this isotherm throughout the year. Thus, sterile flies must be released during periods when the temperature is often below 16 C, about the threshold for wild fly activity. The relative rate of initial dispersal of sterile flies is slower but the pattern of local distribution is similar to the pattern in spring and summer.

1970 DeVaney, J.A., Eddy, G.W., et al.

Olfactory Responses of the Adult Screwworm After Removal of the Antennae, Mouthparts, Tarsi and Legs

J. Econ. Entomol. 63: 1816-19

The removal of certain appendages or segments from adult screwworms and subsequent tests of oviposition, response to baited and unbaited traps, and response to screwworm infested wounds on sheep showed that the more important olfactory receptors are situated on antennae and mouthparts. Removal of only 1 appendage did not reduce egg production drastically, but when both the antennae and mouthparts were removed only 21% of the flies laid egg masses (compared with 93% in controls). Little oviposition occurred when the "antennaless" flies were separate from the egg medium; also these flies didn't discriminate between baited and unbaited traps, nor were they able to locate infested wound. Flies having only 1 antenna removed were able to locate baited traps and infested wounds, but not nearly so well as normal flies. Flies with excised mouthparts responded like normal flies to baited and unbaited traps. The precise location of receptors was not determined but results indicate the necessity of using intact specimens.

- 1971 DeVaney, J.A., Eddy, G.W., et al.
Response of Three Colonies of Screwworm Flies to Proteins and Sugars in a Multiple-Choice Olfactometer

J. Econ. Entomol. 64: 809-812

When responses of 3 colonies of *Cochliomyia hominivorax* (Coquerel) to 10% aqueous preparations of egg albumin, casein hydrolysate, raffinose, or dextrose were tested in a new multiple-choice olfactometer, the 2 laboratory-adapted colonies responded similarly based on the number of flies trapped. However, flies from a more recently colonized group were less responsive, especially when they were less than 5 days old. The colonies did not show a marked preference for any material, nor was response correlated with either sex or age. Improvements in the olfactometer must be made before it would prove satisfactory for screening materials as attractants for the screwworm fly.

- 1973 Fletcher, L.W. and Turner, J.P.
Response of Female Screwworm Flies to a Selected Odor

Ann. Entomol. Soc. Am. 84-85

The diminishing effect on female *Cochliomyia hominivorax* (Coquerel) exposed for short periods to the odor(s) of fermented blood albumin in a field cage that indicated habituation as demonstrated by a waning in response, may have occurred. Even when the interval between tests with the same flies and odors was lengthened from 15 to 75 to 120 minutes, complete recovery did not occur. However, at least 120 minutes were required between test before significant results could be obtained. Female screwworm flies did not respond to the odor(s) unless the minimum temperature was 17.8 C.

- 1973 Grabbe, R.R. and Turner, J.P.
Screwworm attractants: isolation and identification of organic compounds from bacterially inoculated and incubated blood
Folia Entomologia (Abst) 25-26:120-1

Isolation and identification of organic compounds from bacterially inoculated and incubated blood. Ether extract was distilled & fractionated chemically to neutral, acidic, & basic fractions. Neutral fraction was most attractive and was fractionated by prep GLC. Fractions always had less activity than the total neutral mixture which was also passed through GLC. Compounds isolated & identified by infrared spectra & GLC retention time include phenol, p-cresol, & indole. Compounds tentatively identified include skatole & ethanethiol. Although the pure individual compounds were not very attractive at any concentration in aqueous solution or neat, dilute aqueous mixtures of indole, skatole, phenol, and p-cresol were quite attractive to screwworm flies in the lab. The concentration arbitrarily used were 10 mg of each compound in 50 ml of water.

- 1973 DeVaney, J.A., Eddy, G.W., Ellis, E., Harrington
 Attractancy of inoculated and incubated bovine blood fractions to
 screwworm flies: Role of bacteria
 J. Med. Entomol. 10:591-595

Olfactometer tests in the laboratory with bacteria-contaminated citrated whole bovine blood, bacteria-inoculated sterile citrated whole blood, defibrinated blood, and blood plasma indicated that the attractancy of these materials to screwworm flies resulted from the bacteria and/or from the compounds produced by them. Aseptically drawn blood incubated at 37 oC for 7 days was no more attractive than the unincubated blood held at 5 oC. Ranking of attractiveness was bacteria-inoculated sterile defibrinated blood > bacteria-inoculated citrated whole blood > bacteria-inoculated plasma > sterile-incubated defibrinated blood = distilled water.

- 1973 Fletcher, L.W., Turner, J.P., Husman, C.N.
 Surface temperature as a factor in the selection of ovipositional
 sites by three strains of the screwworm
 J. Econ. Entomol. 66:422-423

A test chamber with a controlled heat gradient was used to determine surface temperature effects on selection of ovipositional sites by scr screwworm flies. Range was 30.6 to 36.7 oC. The greatest number oviposited at 33.3 oC. Preferred range was 33.3 +/- 1 oC.

- 1975 Eddy, G.W., DeVaney, J.A., Handke, B.D., Lopez
 Attractants for the screwworm : Irradiation effects on bacteria-
 inoculated media
 Ann. Entomol. Soc. Amer. 68:269-270

A dose of 2000 krad was required to kill bacteria in media prepared from homogenized 3rd-instar screwworm larvae and in sterile whole and defibrinated blood. The production of substances attractive to screwworm flies was reduced when the media were irradiated at 20 krad in 60 Co gamma ray source. However, blood irradiated at 20 krad then inoculated and incubated was more attractive than unirradiated and incubated blood.

- 1976 Jones, C.M., Dehler, D.D. et al.
A Chemical Attractant for Screwworm Flies

J. Econ. Entomol. 69: 389-391

A chemical bait that was as attractive as liver to adult *Cochliomyia hominivorax* (Coquerel) contained 10 chemicals found to be degradation products of animal protein. Best results were obtained by separating the chemicals to 3 vials based on compatibility. In a 20-wk comparison of the chemical bait with liver, the bait attracted 5.7 times more male screwworms, and the liver attracted 1.7 times more females and 7.7 times more trash flies.

- 1977 Coppedge, J.R. and Snow, J.W.

Seasonal response of screwworm adults to two attractants in subtropical Texas

Southwest. Entomologist 2:57-61

The seasonal occurrence of screwworm flies in subtropical Texas was investigated using traps baited with liver and with the chemical attractant "swormlure". Native and released female screwworm flies were captured in all of 52 weeks of the study period (Oct 31, 1974 to Nov 1, 1975). The peak capture of female screwworm flies was in April while the peak capture of native female screwworm flies was in October. In general, the native and released male screwworm flies responded to the traps in much the same pattern as the females although in lower numbers. The seasonal responses of female screwworms to decomposing liver and to swormlure were similar.

- 1977 Guillot, F.S., Coppedge, J.R., et al.

Behavior and Reproductive Status of Native Female Screwworms Attracted to a Host

Ann. Entomol. Soc. Am. 70:588-590

Female screwworms, *Cochliomyia hominivorax* (Coquerel), responding to a wounded host began to feed immediately on the wound exudate regardless of their stage of ovarian development. This behavior was probably related to nutritional requirements for egg maturation. The rather high abundance of vitellogenic, parous females throughout the year may be indicative of limited autogeny. The incidence of mating of females responding to wounds was 100% & 91% for parous and nulliparous females, respectively. Virgin nulliparous females were first captured in Sept. Mating probably occurs when a female screwworm is in the beginning stages of the first gonotrophic cycle.

- 1977 Broce, A.B., Goodenough, J.L., et al.
A Wind Oriented Trap for Screwworm Flies

J. Econ. Entomol. 70: 413-416

A new screwworm trap that catches the flies as they move upwind toward the attractant, Swormlure-2, (SL-2), was developed. This wind oriented trap (WOT) maintains a constant orientation with the wind. It was field tested and compared with the standard blowfly trap (STT). The WOT caught more primary screwworm flies, *Cochliomyia hominivorax* (Coquerel), than the STT in every collection date and was better than or equal to the latter in every trapping site. The WOT caught a lower % (29) and number (7358) of secondary screwworm flies, *C. macellaria* (F.), than the STT (65% and 18906 flies). The WOT caught a lower % of males of both species but caught a greater number of *C. hominivorax* males. The WOT is more efficient in trapping *C. hominivorax* flies, easier to handle, and costs less than the STT.

- 1977 Coppedge, J.R., Ahrens, E., et al.
Field Comparisons of Liver and a New Chemical Mixture as Attractants for the Screwworm Fly
Environ. Entomol. 6: 66-68

A new mixture of the screwworm, *Cochliomyia hominivorax* (Coquerel), chemical attractant was prepared and evaluated under field conditions. This new mixture "Swormlure-2," proved to be more attractive to screwworms than the mixture presently being used and at least as attractive as decomposing liver. In general, more unmated female flies were attracted to Swormlure-2 than were attracted to liver. Also, Swormlure-2 appeared to be more attractive than liver to unmated females that were in early stages of egg development.

- 1977 Guillot, F.S., Coppedge, J.R., et al.
Reproductive Status of Female Screwworms Captured from Hosts or in Traps

Southwest. Entomologist 2: 49-52

Traps baited with liver or a chemical attractant captured fewer post-vitellogenic female screwworms, *Cochliomyia hominivorax* (Coquerel), & more females in the early stages of vitellogenesis than were captured from a host. In addition, more virgin vitellogenic nullipars were captured with baits. The chemical attractant is an effective tool for surveying a reproductively young population of screwworm females during winter when reports of infestations are infrequent.

- 1978 Guillot, F.S., Brown, H.E., et al.
Behavior of Sexually Active Male Screwworm Flies

Ann. Entomol. Soc. Amer. 71: 199-201

Sexually active male screwworms were observed in "waiting stations" from which they darted at any insect flying by. They often returned to the original station or a few cm from it without contacting the intruder. When they did make contact, the encounters were usually characterized by a vigorous wrestling, with the result that the pair of insects fell to the ground and parted. Occasionally, when the encounter involved a female screwworm fly, the pair flew off with the male holding the females's dorsum to a nearby limb where they mated. Males and virgin females were less likely to orient to a host animals than were mated females and were more abundant in vegetation. We suggest that males are more likely to encounter a receptive female from waiting station in vegetation where both sexes feed on nectar or honeydew, than from those on or near hosts.

- 1978 Broce, A.B. and Ideker, J.
Oleander Flowers as Insect Traps

Ann. Entomol. Soc. Amer. 71: 628-629

Flowers of oleander, *Nerium oleander* L., were found with insects trapped inside their corollas. Insects when collecting nectar, insert their mouth parts between stamens near the base of the pistil. When the mouthparts are withdrawn, the labella become lodged between adjacent sagittate anthers and trap the insects. The possible adaptive significance of this trapping phenomenon is discussed. Trapped insects consisted primarily of primary and secondary screwworm flies, *Cochliomyia hominivorax* (Coquerel) and *C. macellaris* (F.), respectively, which comprised 88 % of all trapped flies. The high % of these flies in oleander was due to the high population density of these insects and the scarcity of other food sources.

- 1978 Krafus, E.S.
Aggregations of male screwworm flies, *Cochliomyia hominivorax* (Coquerel) in south Texas (DIPTERA: CALLIPHORIDAE)
Proc. Entomol. Soc. Wash 80:164-170

Noted for the 1st time is the occurrence of aggregations of males of the screwworm fly. The continuous presence of males in each of 2 sites in south Texas was independent of the presence of cattle or of female screwworm flies. Males captured in autumn 1975 proved to be wild; those captured in spring 1976 were released, sterile insects. The behavior of males, wild or sterile, included vigorous conspecific and interspecific interactions. There was evidence of territoriality and competition for favored perching sites. The observations are consistent with an hypothesis that the male screwworm aggregations were mating assemblies similar to those known among other cyclorhaphan Diptera. The significance of male aggregation to sterile fly liberations is discussed.

- 1978 Coppedge, J.R., Broce, A.B., et al.
Development of a Bait System for Suppression of Adult Screwworms

J. Econ. Entomol. 71: 484-485

Through extensive field evaluations, a bait system (hereafter termed "SWASS" for Screwworm Adult Suppression System) was developed for adult *Cochliomyia hominivorax* (Coquerel). SWASS units were a 5.1-cm diam x 7.5-cm cardboard cylinder. Approximately 5 g of a mixture of Elmer's glue (52%), granulated sugar (32%), dried blood (14%), and dichlorvos (2%) were smeared down the center, and a dental roll, ca. 2.5 cm long impregnated with 2 ml of swormlure-2, was placed in the mixture in ca. the center of the cylinder. When SWASS units were first evaluated near the screwworm production plant, they attracted and killed hundreds of released screwworm flies/h. In other field evaluations, SWASS units appeared ca. 70% as effective as a standard trap and ca. 35% as effective as a wind oriented trap when numbers of flies attracted to each trapping system were compared over 1-wk periods. In a field test conducted on a local ranch, native screwworms were attracted and killed by SWASS, 75-80% of the native flies killed with baits were females.

- 1978 Coppedge, J.R., Ahrens, E.H., Snow, J.W.
Swormlure-2 baited traps for detection of native screwworm flies

J. Econ. Entomol. 71:573-575

A survey was conducted in 12 south Texas counties from Jan-Apr 1976 to evaluate swormlure-2 baited traps for detection of native screwworm flies. In 6 of the 12 test counties, native screwworms were caught before the 1st screwworm case was confirmed. In 3 of the remaining 6 counties, native screwworm flies were captured within 10 days after the 1st case was confirmed. In the other 3 counties, screwworm cases were reported several weeks prior to the 1st capture of flies. The information provided by this survey was used by program officials in the operation of the ongoing screwworm eradication program.

- 1978 Coppedge, J.R., Goodenough, J.L., et al.
Evaluation of the Screwworm Adult Suppression System (SWASS) on the Island of Curacao

J. Econ. Entomol. 71: 579-584

SWASS a bait-toxicant system for the screwworm was evaluated on the island of Curacao, Netherlands Antilles. The SWASS units (individual (individual components of the screwworm adult suppression system) were dispersed (10-20/km²) by air over th rural part of the island and by ground (10-20/km²) within its urban areas for a period of ca. 15 wk Feb. 26-May 13, 1977. Collection of adults in survey traps indicated a 65-85% suppression. Reported larval incidence declined 30-70% from that expected. There was an increase in the proportion of males captured in the traps during th period that SWASS units were in the field which reflected the 1 male:5 female kill ratio characteristic of SWASS. In mid-May, the distribution of SWASS was discontinued and releases of sterile flies (1575/km²) were initiated. The releases reduced the residual population of screwworms to insignificant numbers in 3-4 wk, and the island was declared screwworm free on Oct 25, 1977, when over 3 mo had passed without an infested animal being reported.

- 1979 Goodenough, J.L. and Snow, J.W.
 Capture of screwworm and secondary screwworm flies in a time-interval grid trap and correlation with temperature
 J. Med. Entomol. 16: 95-103
 A time-interval electrocutor grid trap was successfully modified to collect adult screwworms, *C. hominivorax*, and secondary screwworms, *C. macellaria*, during 14 hourly diurnal periods. Peak captures of *C. h.* were made in the am but collections of *C. m.* were made in larger and more uniform numbers throughout the day. Total numbers and activity patterns were highly variable day to day. Hourly captures of both spp were positively correlated with increasing temp. in the range of 20 - 33 oC. *C. h.* capture was very low below 20 oC, peaked ca 33 C, and appeared to decrease above 33 C. *C. m.* were detected over a greater temp range, possibly because they were present at much higher numbers. Captures of *C. m.* did not decrease between 33-35 C. A high degree of variation occurred in diurnal pattern of fly activity and nos. trapped even between successive days having identical temp and RH patterns. Relativ humidity did not appear to influence captures, except that captures were zero or extremely low during rains.
- 1979 Holt, G.G., Adams, T.S., et al.
 Attraction and Ovipositional Response of Screwworms, *Cochliomyia hominivorax* (Diptera: calliphoridae), To Simulated Bovine Wounds
 J. Med. Entomol. 16: 248-253
 An olfactometer oviposition bioassay was developed to study behavior of the screwworm fly, *Cochliomyia hominivorax*, in the laboratory. Maximum oviposition (95.5%) occurred when females contacted bovine blood heated to 40 d C; also, bovine blood had the lowest mean attractancey (10.3%) in olfactometer tests. Contact with all test material was necessary to stimulate oviposition. Vat fluid (incubated larval medium containing meat-blood mixture contaminated with larval waste products and microorganisms) had an attractanc of 80.3% but inhibited oviposition at concentration of stimulants were important factors that affected both the attractancy of the test materials and oviposition in the screwworm fly.
- 1979 Broce, A.B., Davey, R.B., et al.
 Plastic Wicks as Dispensers of the Screwworm Attractant, Swormlure-2
 J. Econ. Entomol. 72: 115-118
 Polyester fiber wicks in a propylene skin were superior to cotton dental wicks as a slow release mechanism for the screwworm, *Cochliomyia hominivorax* (Coquerel), chemical attractant, swormlure-2. The cotton wicks released the attractant rapidly due to evaporation over the entire surface area. The plastic wicks released the swormlure-2 at a much slower rate because evaporation occurred only at the exposed ends. The use of plastic wicks in the Screwworm Adult Suppression System (SWASS) units extended the effective life of these units by 4-fold over those using cotton wicks. The use of plastic wicks in reservoir bottles used in screwworm survey traps reduced the quantity of swormlure-2 released by 10-fold without reducing the number of screwworm flies captured. Traps with plastic wicks were easier and safer to service.

- 1979 Adams, T.S., Holt, G.G., Sundet, W.D.
Physical and physiological effects on the response of female
screwworms to carrion odors in an olfactometer
J. Med. Entomol. 15:124-131

An olfactometer bioassay was developed to study screwworm attractants in the laboratory. Maximum attractancy and activity in the olfactometer occurred at a wind speed of 1 m/s, a light intensity of 10.8 lx, a humidity of 50% RH, a temperature of 27 °C, and an exposure time of 15 min. The attractant source was a 25% solution of spent larval rearing medium (vat fluid) applied at a volume of 0.1 cm³ to a water-saturated dental roll. Flies fed on meat or blood were less attracted to vat fluid. It was concluded that vat fluid produced a feeding attractant.

- 1979 Spradbery, J.P.
The reproductive status of *Chrysomya* species (Diptera: Calliphoridae) attracted to liver-baited blowfly traps in Papua New Guinea
J. Aust. Entomol. Soc. 18:57-61

The reproductive status of 5 spp of *Chrysomya* caught in liver-baited traps in Papua was determined. The spp. trapped were *C. bezziana*, *C. megacephala*, *C. saffrana*, *C. rufifacies*, and *C. varipes*. Results were compared with data for *Lucilia cuprina* and *Cochliomyia hominivorax*. Of the total *Chrysomya* catch, only .04% were *bezziana*. Of the 108 *bezziana*, only 1 was male (17-26% males in other spp.). Demonstrates that the male *bezziana* is unresponsive to source of protein. Nulliparous females accounted for 9% of *bezziana* (53-76% for other spp.). This is related to the autogenous nature of the screwworm. Gravid females accounted for 12% of *bezziana* (21-50% of other spp.), 14% in *L. cuprina* and 5% in *C. hominivorax*. Of the 2nd ovarian cycle flies trapped, 98% of *bezziana* were in the early stages of egg development compared with 43-62% in the blowfly spp and *C. hominivorax*.

- 1979 Adams, T.S. and Reinecke, J.P.
The Reproductive Physiology of the Screwworm, *Cochliomyia hominivorax* (Diptera: Calliphoridae) I. Oogenesis
J. Med. Entomology 15: 472-83

Oogenesis in the screwworm fly, *Cochliomyia hominivorax*, was divided into a series of 10 stages, where the germarium was defined as stage 1, the beginning of yolk formation as stage 4, and the mature egg as stage 10. The volume of the nurse cell nuclei was maximum at stage 6 and then started to decrease. However, maximum cytoplasmic volume of the nurse cells was observed in stage 7 follicles. The nurse cells degenerated during stage 9. Chorion formation started in stage 9 follicles and was completed by stage 10. The number of follicle cells increased during stages 2, 3, and 4 and decreased during stages 6-10. The follicle cells over the nurse chamber were squamous during stages 6-9. During stages 6 and 7, the follicle cells over the oocyte were columnar; during stage 8, they were cuboidal, and during stages 9 and 10, they became elongated.

- 1979 Broce, A.B., Goodenough, J.L., Snow, J.W.
 Recovery of screwworm flies released at various distances and
 directions of the attractant swormlure-2
 Environ. Entomol. 8:824-828

Sterile screwworm flies dye-marked and released 50 m upwind and at both sides crosswind of the screwworm chemical attractant swormlure-2 were captured at rates of 13, 3, 27.4, and 14.3% respectively, of those released downwind of the attractant, indicating that flies moved in all directions immediately after release. When released at 9 distances, 50-350 m downwind of the attractant source, recaptures of flies released 50-125 m were initially high but decreased rapidly. Recaptures of flies released 150-350 m downwind of the attractant were initially low and remained ca constant. Flies released at 150 m and beyond, apparently first dispersed at random from the release point and then were captured only after entering the odor plume. It was inferred that the odor plume or instantaneous area of influence of swormlure for detection and attractancy by sterile screwworm flies extended 125-150 m downwind of the attractant source.

- 1980 Broce, A.B.
 Sexual behavior of screwworm flies stimulated by swormlure-2
 Ann. Entomol. Soc. Amer. 73:386-389

Males of the screwworm fly, *Cochliomyia hominivorax*, were sexually stimulated by the chemical attractant swormlure-2, reaching a significant level of sexual response when 3 d old. Females started responding when 2 d old, but their responses did not appear to be sexually related. Males responded strongly to stimulation by some of the individual components of swormlure, namely sec-butyl alcohol, butyric acid, valeric acid, p-cresol, and indole. Females responded strongly to stimulation by dimethyl disulfide, p-cresol, and acetic acid. The biological significance of swormlure-2 in the behavior of screwworm flies is perhaps that it mimics the odor of an aggregation site (flowers).

- 1980 Spencer, J.P., Whitten, C.J., Coppedge, J., Snow
 Comparison of screwworm captures in liver- and swormlure-baited traps
 in a tropical area of southern Mexico
 Southwest. Entomologist 5:175-178

In a field comparison conducted in a coastal area of Chiapas, Mexico, screen traps baited with liver and wind-oriented(WO) traps baited with swormlure-2 caught equal numbers of screwworms. However, the liver-baited traps caught significantly more *C. macellaria*, sarcophagid spp, and other miscellaneous flies than the WO traps, which greatly increased the time required for fly identification. In a 2nd test, plastic wicks and cotton wicks used as swormlure-dispensers were equally effective in attracting female screwworms, but plastic wicks were significantly more effective in attracting screwworm males as evidenced by trap captures.

- 1981 Coppedge, J.R., Brown, H.E., et al.
Bait Stations for the Suppression of Screwworm Populations

J. Econ. Entomol. 74: 168-172

Bait stations were prepared and evaluated for field effectiveness against *C. hominivorax*. Each bait station consisted of a paper cone (15 cm diameter) covered on top with ca. 50 g of feeding bait-toxicant mixture (dried blood, sugar Elmer's glue, dichlorvos) suspended over a cup of solidified swormlure-2 (75% swormlure-2, 25% American Hoetsch KSL wax). In the initial field evaluation, bait stations were equal in effectiveness to wind-oriented traps for killing or capturing screwworms, and were 6 X more effective against secondary screwworms, *C. macellaria*. Chemical assay indicated that bait stations should attract and kill screwworm flies for 45 - 60 da. In 2 other field tests, the toxicant in the bait stations was replaced with sodium fluorescein dye. In the 1st test, bait stations were placed in groups of 4 near live-stock watering areas; 18% of *C.h.* and 20% of *C.m.* captured during 30 da were dye marked. In the 2nd test bait stations were placed at random and 25% of *C.h.* and 31% of *C.m.* were dye marked.

- 1981 Spencer, J.P., Snow, J.W., Coppedge, Whitten
Seasonal occurrence of the primary & secondary screwworm in the Pacific coastal area of Chiapas, Mexico during 1978-1979
J. Med. Entomol. 18:240-243

During 1978 in the Pacific coastal area of Chiapas, Mexico, population of the primary screwworm, *Cochliomyia hominivorax*, reached seasonal highs in July & November-December and a seasonal low in April. Secondary screwworm, *C. macellaria*, population trends were similar, peaking in July & November with a seasonal low in March. Collection of egg masses from sheep showed a 98+% natural viability rate. Data from trap captures and sentinel animals indicate the presence of a resident population sufficient to provide the base for a buildup in screwworm infestation at any time during the year.

- 1982 Mackley, J.W. and Snow, J.W.
Effects of Cattle Dung on the Behavior and Survival of Adult Screwworms and on the Development of their Eggs
Environ. Entomol. 11: 432-435

Fifty-six percent of sterile adult screwworms, *Cochliomyia hominivorax* (Coquerel), collected with a sweep net from cattle dung and vegetation at cattle-congregating areas in South Texas were mated females. No mating activity was observed at these sources. Collections from a wind-oriented trap baited with swormlure-2 and from dung yielded 3.7 and 11.6% males, respectively; these sex ratios were considered similar enough to suggest that some chemical components of swormlure-2 and dung may be related. Aging of dung reduces its attractiveness. Dung contributes little to screwworm survival and is an inadequate nutritional source for egg development in the second gonotrophic cycle. Dung may aid females in locating potential hosts.

- 1982 Snow, J.W., Coppedge, J.R., Broce, A.B., et al.
 Swormlure: Development and use in detection and suppression systems
 for adult screwworm (Diptera: Calliphoridae)
 Bull. Entomol. Soc. Amer 28:277-284

A review of the development and uses of the chemical mixture known as swormlure through 1981. Includes the development and deployment of SWASS.

- 1982 Peterson, R.D.II
 Influence of Trap Color and Height Above Ground on Capture of
 Screwworms

Southwest. Entomologist 7: 240-243

Studies were conducted in South Texas and in Sinaloa, Mexico to determine the influence of trap color and height above ground on the capture of screwworms in wind oriented traps. In the color preference test, the overall distribution of trapped, *Cochliomyia hominivorax* (Coquerel), was yellow (24%), standard (22%), white (21%), green (16%), black (9%) and red (8%). There were 2X more females caught/trap/day in single traps hung 0.40 m above ground than in traps hung at the standard height of 1.5 m.

- 1983 Brown, H.E. and Mackley, J.W.
 Changes in Attractancy and Chemical Composition of the Screwworm
 Chemical Attractant, Swormlure-2, under Field Conditions

J. Econ. Entomol. 76: 1273-78

Swormlure-2 (SL-2), the chemical attractant of adult screwworms, was 17 to 56% more attractive during the 1st 5 d of field exposure than SL-2 exposed only 1 or 2 d. Attractancy declined steadily after 5 d, after 11 d, it was 50% as attractive. Sex ratios were not affected by changes in attractancy. 40.5% evaporated during 1st 5 days. Group I chemicals (iso-butanol, sec-butanol, dimethyl disulfide, acetic acid, butyric acid) exhibited high evaporation rates at the outset. Group II chems. (phenol, valeric acid, p-cresol, benzoic acid, indole) exhibited low, relatively constant evaporation rates and comprised 52.7% of the vapor as exposure time increased. Attractancy and Group I dosage were positively correlated but attract. and Group II dosage were not. Loss of attractancy may have resulted from increased Group II dosage. The loss, therefore, appeared to result from changes in composition, but not decreases in dosage of vapor. Temperature and wind were the main weather related factors affecting evaporation.

- 1983 Foss, D.K., McDonald, I.C., Bromel, M., Gassner
Isozyme variation among bacterial isolates originating from the
screwworm fly
Environ. Entomol. 12:1773-81

Isozyme surveys were used to compare genetic variation within and among strains of the bacterium *Proteus rettgeri*. 1 strain was a standard American Type Cell Culture strain, whereas 8 other strains were recovered from larva or pupa of the screwworm of varied geographic or animal host origins. Observations of 16 different enzyme systems of each bacterial isolate revealed extensive inter- & intrastrain variation in the numbers or positions of enzyme bands recorded among samples from different phases of culture growth media. Similar differences were likewise noted among strains when they were sampled at the same growth phase. Hierarchical clustering and multidimensional analyses of the data produced groupings of the bacterial strains which suggested that their enzyme patterns were influenced by factors related to their geographic distribution or their animal host origins.

- 1983 Baumgartner, D.L. and Greenberg, B.
The Primary Screwworm Fly, *Cochliomyia Hominivorax* (Coquerel) (Diptera, Calliphoridae), in Peru
Rev. Brasil. de Biol. 43:215-221

Cochliomyia hominivorax larvae and adults were collected in hemi- and asynanthropic sites in the lower jungle near Puerto Bermudez and the upper jungle near San Ramon, areas with an emerging livestock industry. This is the first substantiated record of the primary screwworm from Peru. Among several baits tested, including Swormlure-2, only fish, liver, and human feces proved attractive. Swormlure-2 attracted no other blow flies, except a few *C. macellaria* and *Chloroprocta idioides*. *C. hominivorax* represented 1.8 percent (winter, Pt. Bermudez), 0.10 percent (summer, Pto. Bermudez), and 0.38 percent (summer, Pto. San Ramon) of the total blow flies collected. The myiasis wounds were small, circumscribed, odorless, had relatively few larvae, and healed quickly following insecticidal treatment. Genitalia of reared flies from two sites differ in epiphallus angle and apodeme shape. Important economic & biological questions are raised by these findings.

- 1983 Peterson, R.D.II, McInnis, D.O., Whitten, C.J.
Dispersal and Distribution of Ground Released Screwworms *Cochliomyia hominivorax* (Diptera: Calliphoridae) in South Texas
APHIS Series. 91-57 11 pp
In 1980, 2 mark-release-recaptures of ground released adult screwworms *Cochliomyia hominivorax* Coquerel, were made at the King and Novillos ranches in south Texas to study dispersal patterns of the sterile flies. During the first release, drought conditions (temp. 38 C mean max, precipitation < 1mm) reduced trap captures. Only 0.53% of the flies released were recaptured, and of these, 87% collected the day following the release. Most flies at King were recaptured inside the 3 release blocks (65 km²), however 14% of the flies recaptured from 1 block release were captured outside the block. Dispersal patterns appeared to be correlated with wind direction. During release 1, flies moved with the 20 km/hr, S-E winds (prevailing 90% of the time) and some flies moved 12 km for a release point. No flies from north block release were captured the south block. Temperature moderation and rainfall (Hurricane Allen) made conditions more favorable for fly survival during the 2nd release.

1983 Hammack, L. and Holt, G.G.

Responses of gravid screwworm flies to whole wounds, wound fluid, and a standard blood attractant in olfactometer tests

J. Chem. Ecology 9: 913-922

Laboratory olfactometer bioassays were used to study attractiveness of whole animal wounds, wound fluid, and reconstituted dried blood to gravid screwworm flies, *Cochliomya hominivorax* (Coquerel). Flies were attracted to odors from whole wounds that were infested with screwworm larvae but not to those from uninfested wounds that were 0-2 days old. A maximum of 59% of females were attracted to fluid from screwworm infested wounds and the response changed little over fluid concentrations from 3.3 to 100%. However, blood tested over a similar concentration range yielded a significant linear relationship between log dose and response. Peak attraction was 82%. Attractancy of fluid collected from infested wounds declined when the fluid was stored at -20 C for more than four weeks but attractancy of a stored blood sample remained unchanged from three months. The blood attractant(s) was also heat stable and is suitable for use as a reference standard in bioassays.

1983 Flath, R.A., Mon, T.R., Whitten, C.J., et al.

Volatile Components of Acacia sp. Blossoms

J. Agric. Food Chem. 31: 1167-70

Volatile component mixtures from the blossoms of three different *Acacia* sp. were examined and compared by capillary gas chromatography/mass spectrometry. Blossoms of *Acacia berlandiere* Benth. and *Acacia rigidula* Benth. are attractive to the screwworm fly *Cochliomyia hominivorax* (Coquerel), while those of *Acacia farnesiana* (L.) Willd. are inactive.

A total of 114 compounds was identified in the three concentrates. Fourteen of these were found in concentrates from the two active species but could not be detected in the volatile concentrate from *A. farnesiana* blossoms. They include trans-5-ethenyl-tetrahydro-a,a,5-trimethyl-2-furanmethanol (linalool oxide A), 2-phenylethanol, trans,cis-2-6-nonadien-1-ol, cis-6-ethenyltetrahydro-2,2,6-trimethyl-2H-pyran-3-ol (linalool oxide D), 1-nonanol, 1H-indole, trans,trans-2-4-nonadienal, eugenol, benzyl 2-methylbutyrate, jasmone, geranylacetone, cis-3-hexenyl benzoate, hexyl benzoate, and benzyl salicylate.

1983 Mackley, J.W. and Long, G.L.

Behavior of sterile adult screwworms (Diptera: Calliphoridae) on flowering trees and shrubs

Ann. Entomol. Soc. Amer. 76:839-843

In a south Texas shrub and brush community, sterile adult screwworms were observed or collected on 19 of the 23 sampled species of flowering shrubs and trees. Flies were observed feeding, mating, and resting on flowering shrubs and trees. Most of the flies were found on tenaza, coyotillo, and certain *Acacia* spp, but not on flowering cacti, herbaceous wild flowers or grasses. Fly activity on a given plant species appeared to be related to blooming patterns and possibly flower color, but activity was not correlated to the density, frequency, or % coverage of a plant sp. Fewer females were collected (46.1%) and < 1/2 were mated. Flies appeared to aggregate, feed, and mate at local flowering vegetation for up to 5 days after eclosion.. No activity other than resting was observed when plants were not in flower, except at 2 locations where males were waiting for females on nonflowering veg. The effect of season & rainfall on flowering could have indirectly affected activity, particularly survival, as flowers are major feeding sites

1983 Bromel, M., Duh, F.M., et al.

Bacteria associated with the screwworm fly (*Cochliomyia hominivorax*) (Coquerel) and their metabolites

Endocytobiology II:791-800

All stages of the life cycle and larval environments of the screwworm fly were subjected to bacteriological analysis. Samples of egg masses, larvae, pupae, adult flies, wound fluid from infested animals and vat rearing fluid were obtained from USDA Texas, Mexico or N. Dakota rearing facilities or from field collection in Texas and Mexico. Bacteria were isolated with standard bacteriological techniques and identified with computerized numerical identification systems. Highest counts were found in the laboratory reared larvae and field-collected pupal stages. Lowest counts were determined from the eggs. *Proteus mirabilis*, *Providencia stuartii* and *Providencia rettgeri* occurred as codominants in eggs, larvae, and pupae. *P. mirabilis* and *P. rettgeri* were the most frequently isolated species from larval growth environments. A bactericidal metabolite from all *P. mirabilis* isolates killed pyogenic bacteria (streptococci and staphylococci) in 4 min. Olfactometer studies indicated that culture media from *P. rettgeri* was attractive to gravid flies

1984 Mackley, J.W. and Brown, H.E.

Swormlure-4: A new formulation of the swormlure-2 mixture as an attractant for adult screwworms, *Cochliomyia hominivorax*

J. Econ. Entomol. 77:1264-8

Fifteen candidate mixtures in which the ratios of the 10 components found in swormlure-2 (SL-2) were altered & compared with SL-2 for attractiveness to adult screwworms. The most attractive mixture (SL-4) differed from SL-2 in that it contained higher amounts of the components with the 4 lowest boiling points (bp) and lower amounts of the comp. with the 6 highest bp. Wind-oriented (WO) traps baited with SL-4 captured 40 & 81% more sterile and wild screwworm flies respectively, than SL-2 baited WO traps. Sex ratios for sterile & wild flies captured in SL-4 & SL-2 traps were similar. SL-4 captured 19% more *C. macellaria* & 28% more "other diptera". SL-4 was almost 2X as volatile as SL-2. Dosage & response for SL-4 & SL-2, respectively, showed some positive correlations; we concluded that both the new composition & higher dosage were responsible for the increased attractiveness of SL-4.

1984 Hammack, L.

Relationships of larval rearing variables to fly attraction and oviposition responses in the screwworm, *Cochliomyia hominivorax*

J. Med. Entomol. 21:351-356

Responsiveness of gravid screwworm flies in oviposition and olfactometer bioassays was examined in relation to mean larval wt, mean pupal wt, and survival to pupal stage in the larval rearing groups that supplied the test females. Weights were not of value for predicting adult behavior in bioassays, but the % of insects surviving from egg to pupal stage was positively and linearly correlated with oviposition and attraction responses ($r^2 = 0.48$ and 0.57 , respectively)..... Survival in larval groups did not vary with parental age at oviposition or with the temp at which parental insects had been held as pupae but circumstantial evidence suggested that composition of the larval starting diet affected survival and adult behavior.

1986 Mackley, J.W.

Incidence of the screwworm, *Cochliomyia hominivorax*, and the secondary screwworm, *C. macellaria*, in the central highlands of Chiapas, Mexico
J. Med. Entomol. 23:76-82

In a 12 mo survey in the central highlands of Chiapas (470-2270m elev) 100 adult screwworms (0.058 adults/trap/wk) & 1155 adult *C. macellaria* (0.671 adult/trp/wk) were captured in wind-oriented traps baited with swormlure-2. Captures of the 2 spp were not correlated with elevation; instead adults appeared to occur in "pockets" along the altitudinal gradient. More adults were captured during the wet season than in the dry season; seasonal differences in captures were greater at elev. 1470-2270m than from 470-1270m. Adult capture rates (ACR) for screwworms were not correlated with ave mo temp or rainfall at low elev but showed a positive corr at high elev. These differences were believed to be due to greater annual changes in weather at high elevations. ACR's for *C. macellaria* were not correlated with the average monthly temperature or rainfall at either the high or low elev. Screwworm oviposition showed a negative correlation with elev., a possibly sig neg corr with ave. da precip, & pos corr with temperature.

1987 Hammack, L., Bromel, M., Duh, F.M, Gassner, G.

Reproductive factors affecting responses of the screwworm fly, *Cochliomyia hominivorax*, to an attractant of bacterial origin
Ann. Entomol. Soc. Amer. 80:775-780

Attraction of screwworm flies, *C. hominivorax*, to steam distillate of culture medium inoculated with the bacterium, *Providencia rettgeri*, was studied in laboratory olfactometer assays conducted with 0- to 12-day old males and nulliparous females. Males, and females with previtellogenic ovaries, were not attracted. Those with vitellogenic ovaries demonstrated only a trace response. Females became gravid as early as 4-5 days, but the percentage of gravid females attracted increased linearly with age up to 10 d. Insemination significantly enhanced responsiveness without affecting the rate of ovarian development. Gravid mated females 10-12 d old were the most strongly attracted. The results were consistent with the hypothesis that bacterial metabolites contribute to the attractiveness of wounds on screwworm host animals.

1987 Peterson, R.D., Mackley, J.W., Candido, A.O.

Sugar feeding by adult screwworms and its effect on longevity and oocyte maturation

Ann. Entomol. Soc. Amer. 80:130-135

Because primary feeding by the screwworm on carbohydrate sources is essential to survival and reproductive success, we undertook studies to determine in the lab the feeding preferences for 0.1 and 0.3 M sugar solutions and their effect on longevity and oocyte maturation. Fertile flies 2-10 d old were fed 0.1 M sol. of either sucrose, fructose, glucose, maltose, or lactose. There was no significant difference between males in their consumption of sucrose and maltose. Females preferred maltose to sucrose. Glucose and lactose were least preferred by both sexes. Flies fed 0.1 M fructose showed the greatest median survival of 19 d, comparable with that of honey. Except for lactose survival was greater with increase in conc. Overall flies survived longer on honey than on the test sugars. None of the 0.1 M solutions were adequate for females to develop eggs to a mean stage of 10. Females fed 0.3 M maltose, sucrose and fructose developed mature eggs by age 10 d. Honey was superior for egg maturation.

- 1987 Eisemann, C.H. and Rice, M.J.
The origin of sheep blowfly, *Lucilia cuprina* (Diptera: Calliphoridae),
attractants in media infested with larvae
Bull. Entomol. Res. 77:287-294

Laboratory bioassays with gravid females of *Lucilia cuprina* were used to isolate the source(s) of olfactory attractants emanating from larvae infested media. Adults were not attracted by odours from axenic (microorganism-free) larvae, but volatiles from xenic larvae were highly attractive. The attractants proved to be kairomones, not pheromones, as odours from other species of calliphorids and a sarcophagid species were also attractive.....The order of attractiveness was: xenic with larvae >> xenic without larvae > axenic with larvae > axenic without larvae. It is concluded that larvae infested media owe their great attractiveness to the volatiles produced by the action of microorganisms, not to specific larval volatiles. Larval activity accentuates the output of attractive volatiles from both xenic & axenic proteinaceous media.

- 1989 Hammack, L.
Protein feeding and oviposition effects on attraction of screwworm flies (Diptera: Calliphoridae) to host fluids
Ann. Entomol. Soc. Amer. submitted
Olfactometers were used to study effects of protein feeding & oviposition on attraction of screwworm flies to host blood and wound fluids. The size of the protein meal taken at various physiological stages & the temporal relationship between feeding & oviposition were examined. Engorgement accompanied oviposition on a proteinaceous substrate, & ca 80% of time feeding in association with oviposition occurred during & immed. after egg-laying. Oviposition with feeding reduced attraction, oviposition did not. Protein feeding 60-90 min before bioassay reduced attraction of vitellogenic nullipars but not gravids; reduced gravid responsiveness was detected 30 min after feeding. Pattern correlated with the reluctance of gravids, unlike vitellogenics or those that oviposited, to engorge fully. The rapidity with which engorgement followed ovip. suggested that gravids are protein hungry. The tests confirmed existence of a screwworm feeding attractant & showed how such a might attract both non-gravids & gravids seeking ovipositional sites.

- 1989 Thomas, D.B. and Mangan, R.L.
Oviposition and wound visiting behavior of the screwworm fly, *Cochliomyia hominivorax* (Coquerel)
Ann. Entomol. Soc. Amer. submitted
Female screwworms visit wounds of warm-blooded animals both to feed & to oviposit, with feeding occurring 2X as often as oviposition. Feeding avg. 5.4 min; oviposition avg. 15.4 min but visits for either may last up to 1 hr. Screwworms are iteroparous with ovip. occurring on a 3 da cycle. 1 female was recorded to live 33 da & ovip. 8X. Ovip activity by the population followed a 17-19 da cycle. Clutch size is variable from 28-492 eggs (mean = 200). Females deposit their clutch in 1-4 masses of eggs, usually on the margin of a wound. If a wound is preoccupied by an egg mass, an ovipositing female will place her egg mass on top of or in direct contact with the prior mass 67% of the time. Thus, the presumption of 1 egg mass equaling the reproductive output of a single female is invalid. Female screwworms combine longevity and iteroparity with autogeny and large clutches. This reproductive behavior is well adapted for exploitation of an ephemeral resource such as wounds on living animals.

DRAFT OF PROPOSED AGENDA AND LIST OF PARTICIPANTS FOR SCREWORM
ATTRACTANTS WORKSHOP

OBJECTIVE: To clarify the status of attractants research for screwworms
and to identify needs for successful completion of research.

PARTICIPANTS:

FARGO	MEXICO	OTHER
Whitten	Mangan	Bram (NPS)
Hammack	Parker	Flath (WRRRC)
Peterson	Mackley (APHIS)	Gainesville rep.
Pomonis	Hofmann (APHIS)	
Gassner		

AGENDA:

1. Where are we now?
Swormlure - Mackley/Whitten
Wound Attractants - Hammack, Pomonis, Flath
Artificial Wound - Mangan, Parker
Plant Attractants - Peterson, Mangan, Parker
Other (Feeding, oviposition, etc.) - ??
2. Are we going in the right direction?
3. Where do we go from here? (Establish priorities)
4. Resources necessary
 - a. Available
 - b. Needed
5. Workshop summary - Bram

Comments: Ralph, I realize that this is not polished and ready, but I do believe that we can start with this concept. The above participants should be a good blend of lab and field entomologists, chemists, and project or program managers. I feel that it will take at least 1 1/2 days to do a good job on this. Thinking overnight (and over-dinner) what was brought up during the day could sharpen ideas and cooperation for next day's session.

ARS SCREWORM ATTRACTANTS WORKSHOP

SUMMARY REPORT

Fargo, ND, Oct. 4-5, 1988

1. Executive Summary:

A workshop to discuss the status, needs, and priorities of research on attractant systems for screwworms was held in Fargo, ND, Oct. 4-5, 1988. The major goal of the workshop was to identify the attractant research necessary to improve detection and monitoring of adult screwworm populations for eradication and research programs. Participants included 18 ARS and APHIS entomologists, chemists, or geneticists from the U.S., Mexico, and Costa Rica. The main topics were swormlure (the synthetic chemical attractant), wound attractants, artificial wounds, and plant attractants. The requirements for future activities, expressed in priority order, are: (1) a field comparison of known and potential attractants to determine the relative effectiveness of each in order to evaluate whether further research is appropriate, especially in existing systems; (2) long term studies to define host related attractant phenomena; (3) a medium term study of wound ecology; and (4) a continuation of deriving attractant information from population ecology studies in the field. The research is to be accomplished by scientists assigned to Mexico, Costa Rica, and/or Fargo screwworm research laboratories as determined by available resources.

2. Workshop Objectives:

1. To review the present status of screwworm attractants research,
2. To identify new areas of research which will produce technologies applicable to the screwworm eradication program,
3. To establish priorities and define requirements for the successful completion of this research.

3. Participants and Agenda: See Appendices I and II.

4. Results for Objective 1. Review of Present Status

Swormlure - Currently, a wind-oriented trap (WOT) baited with swormlure-4 (SL-4) is the standard screwworm trapping system used by the research and eradication programs to trap male and female screwworms. However, this system, which performed adequately in more arid environs, does not appear to be as effective in the more tropical areas. Swormlure is the primary attractant ingredient used in SWASS, deployed for screwworm population suppression at critical times. The evolution of SL-4 and results of unpublished research were discussed. SL-4 is the most effective swormlure formulation

developed and is 35-50% more effective than SL-2. Apparently, all 10 components of the SL-4 chemical mixture are necessary as omission of any one results in a 50% reduction in effectiveness. Attempts to incorporate SL-4 into slow-release formulations have not been successful, probably because of the caustic nature of the chemical components and the volume necessary. The attraction mechanism (plant or animal related) of swormlure is uncertain. CSIRO scientists in New Guinea are also using SL-4 but with a different trap design; their data indicate that the trapping system is less effective than wounded animals for collecting Chrysomya bezziana, the Old World screwworm. Neither ARS nor CSIRO have current efforts to improve swormlure.

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Artificial Wounds - Collections of screwworm eggs are needed to determine the efficiency of the sterile fly release program as it proceeds into new areas of Central America. The development of a system to duplicate animal wounds is becoming more imperative not only because of the high cost of maintaining wounded animals but also because of recent legislation and public concern about using animals for research purposes. Initial attempts to develop a workable model of an artificial wound has been hindered by the lack of information about ovipositional and feeding stimuli. Some screwworm eggs have been collected by using meats placed inside a heated unit. However, oviposition by other blow fly species has reduced the efficiency of these devices. When information becomes available on the factors that influence egg deposition, more serious attempts to develop an artificial device to collect eggs will be pursued. Presently, a trap designed to be attached over the wound of the sentinel animal is being used to collect flies responding to the wound.

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Other Attractants - The response to any of the above attractants may well be explained by a feeding response and, if physiological conditions for the screwworm female and the nutrient source (ie. the wound) are correct, oviposition may occur. In Costa Rica, a screwworm adult feeding station containing rotting liver has attracted significantly more screwworms than a wounded animal.

5. Results for Objective 2. Identification of Needed Research

A. Swormlure:

1. Analyze volatiles of SL-4 with time to improve chemical formulation.
2. Test grouping of chemicals to improve effectiveness.
3. Improve trap design and formulation for slow release.

B. Wound Attractants

1. Is swormlure as effective as wounded animals, liver feeding stations, or dried blood?
2. Define host related phenomena
 - a. Attraction
 - 1) Develop bioassay.
 - 2) Sampling and collecting potential volatiles.
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3. Wound Ecology

- a. Larval effects
- b. Bacterial effects
- c. Host physiology

C. Artificial Wounds

- 1. Ovipositional and feeding stimuli
 - a. Chemical aspects (to include fresh whole blood).
 - b. Physical aspects
 - c. Behavioral aspects (physiological controls).
- 2. Design concepts (mechanical aspects).

D. Plant Attractants

- 1. Determine (identify) plants most frequently visited.
- 2. Identify stimuli responsible for response (ie. color, shape, odor, etc.).
- 3. Apply procedure used for wound attractant attraction components as applicable leading to field evaluation.

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- 1. Test effectiveness of SL-4 in comparison with wounded animals, liver feeding stations, and dried blood in the 3 different ecological zones of Central America. (B.1 above) To be done in Costa Rica through cooperative effort of ARS and APHIS locations in Mexico.
- 2. Define host related phenomena. (B.2) Long term project with probable interaction of Fargo (such as the development of a wind-tunnel study) and Costa Rica (biological and physiological aspects) laboratories with cooperation of Mexico laboratory.
- 3. Wound ecology. (B.3) Medium term commitment with primary work proposed for Fargo (with the possibility of the assistance of a microbiologist) and the cooperation of the Mexico laboratory.
- 4. Improvement of swormlure. (A.1-3) Dependent on results of Priority 1 (ie. if swormlure shows potential).
- 5. Artificial wounds. (C.1-2) Low input - sideline activity with field studies in Mexico and Costa Rica.
- 6. Plant attractants. (D.1-3) Adult screwworm-plant relationships are important in population ecology studies in Central America; significant results could increase priority for further attractancy studies.

APPENDIX I

LIST OF WORKSHOP PARTICIPANTS

Adams, T.S.	Research Entomologist	ARS, Fargo, ND
Ashley, T.	Entomologist	APHIS, Tuxtla-Gtz., Mexico
Bram, R.A.	National Program Leader	ARS, Beltsville, MD
Flath, R.A.	Research Chemist	ARS, Albany, CA
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Hammack, L.	Research Entomologist	ARS, Fargo, ND
Hofmann, H.C.	Staff Entomologist	APHIS, Mexico City, Mexico
Mackley, J.W.	Entomologist	APHIS, Tuxtla-Gtz, Mexico
Mangan, R.L.	Research Entomologist, RL	ARS, Tuxtla-Gtz., Mexico
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Peterson, R.D.	Research Entomologist	ARS, Fargo, ND
Pomonis, J.G.	Research Chemist	ARS, Fargo, ND
Schmidt, C.H.	Research Entomologist	ARS (Ret), Fargo, ND
Tumlinson, J.H.	Research Chemist	ARS, Gainesville, FL
Whitten, C.J.	Research Entomologist	ARS, Fargo, ND

APPENDIX II

ARS WORKSHOP ON ATTRACTANTS FOR SCREWORMS

O'Leary Room, Kelly Inn
Fargo, ND
October, 4-5, 1988

AGENDA

OCTOBER 4 - C.J. Whitten, Chairperson

8:30	Opening and Introductions	
	<u>Status Reports</u>	
8:45	Status Report on Swormlure	Mackley/Whitten
9:15	Discussion	Participants
9:30	Status Report on Wound Attractants	Hammack/Pomonis/Flath
10:00	Discussion	Participants
10:15	BREAK	
10:30	Status Report on Artificial Wounds	Mangan/Parker
11:00	Discussion	Participants
11:15	Status Report on Plant Attractants	Peterson/Parker
11:45	Discussion	Mangan Participants
12:00	LUNCH - Kelly Inn	
1:30	Status Report on Other Attractants (Feeding, Oviposition, etc.)	Peterson/Hammack
2:00	Discussion	Participants
	<u>Identification of Needed Research</u>	
2:15	Swormlure	Participants
2:45	Wound Attractants	Participants
3:15	BREAK	
3:30	Artificial Wounds	Participants
4:00	Plant Attractants	Participants
4:30	Other Attractants	Participants
	DINNER - Trader & Trapper, Moorhead	Participants

October 5 - Ralph Bram, Chairperson

Priorities and Resources

8:30	Establish Research Priorities	Participants
9:30	Determination of Resources	Participants
10:00	BREAK	
10:15	Areas of Cooperation and Interaction	Bram
10:45	Workshop Summary	Bram
	LUNCH	

Remainder of available time for participants tour of screwworm lab,
Biosciences Research Lab and/or visitation with scientists.

ARS SCREWORM ATTRACTANTS WORKSHOP

SUMMARY REPORT

Fargo, ND, Oct. 4-5, 1988

1. Executive Summary:

A workshop to discuss the status, needs, and priorities of research on attractant systems for screwworms was held in Fargo, ND, Oct. 4-5, 1988. The major goal of the workshop was to identify the attractant research necessary to improve detection and monitoring of adult screwworm populations for eradication and research programs. Participants included 18 ARS and APHIS entomologists, chemists, or geneticists from the U.S., Mexico, and Costa Rica. The main topics ^{discussed} were swormlure (the synthetic chemical attractant), wound attractants, artificial wounds, and plant attractants. The requirements for future activities, ~~expressed~~ ^{evaluation} in priority order, are: (1) a field ~~comparison~~ ^{evaluation} of known and potential attractants to determine the ^{ir} relative effectiveness ~~of each~~ and ~~in order to evaluate~~ whether further research is appropriate, especially in existing systems; (2) long term studies to define host related attractant phenomena; (3) a medium term study of wound ecology; and (4) ~~a continuation of deriving attractant information from~~ ^{the collection of} ~~population ecology studies in the field.~~ ^{field} The research is to be accomplished by scientists assigned to Mexico, Costa Rica, ^{and} or Fargo screwworm research laboratories as determined by available resources.

2. Workshop Objectives:

- 1. To review the present status of screwworm attractants research,
- 2. To identify new areas of research which will produce technologies applicable to the screwworm eradication program,
- 3. To establish priorities and define requirements for the successful completion of this research.

3. Agenda and Participants: See Appendices ^I ~~X~~ and ^{II} ~~Z~~. *where is No. II*

4. Results for Objective 1. Review of Present Status

Swormlure - Currently, a wind-oriented trap (WOT) baited with swormlure-4 (SL-4) is the standard screwworm trapping system ~~utilized~~ ^{used} by the research and eradication programs to trap male and female screwworms. However, this system, which performed adequately in ~~more~~ arid environs, does not appear to be as effective in ~~the more~~ tropical areas. Swormlure is the primary attractant ingredient used in SWASS, deployed for screwworm population suppression at critical times. The evolution of SL-4 and results of unpublished research were discussed. SL-4 is the most effective swormlure formulation developed and is 35-50% more

effective than SL-2. Apparently, all 10 components of the SL-4 chemical mixture are necessary as omission of any one results in a 50% reduction in effectiveness. Attempts to incorporate SL-4 into slow-release formulations have not been successful, probably because of the caustic nature of the ~~chemical~~ components and the volume ^{of attractant} necessary. The attraction mechanism (plant or animal related) of swormlure is uncertain. CSIRO scientists in New Guinea are also using SL-4 but with a different trap design; their data indicate that the trapping system is less effective than wounded animals for collecting Chrysomya bezziana, the Old World screwworm. Neither ARS nor CSIRO have current efforts to improve swormlure.

Wound Attractants - In the field, female screwworms respond to animal wounds for oviposition and feeding. In the lab, gravid or vitellogenic non-fed (protein source) females have demonstrated a response to wound fluids, air passed over active wounds, navel cord preparations, culture preparations of the bacterium Providencia rettgeri, and dried bovine blood. No olfactory response was reported for fresh wounds or whole blood. ~~The results suggest~~ ^{ing the} involvement of bacterially ^{in the attraction} generated products. The least variable and most linear dosage related response was elicited with the dried blood. For this reason and due to the ample supply of the product, subsequent research has utilized the dried blood as the standard for laboratory studies. ~~Basically,~~ ^{the} Total activity of the blood can be recovered in steam distillate ~~preparations~~ and after HPLC fractionation of the distillate, 4 active HPLC fractions appear to be synergistic in combinations. Preliminary tests with dried blood preparations have not demonstrated attraction in the field. The role of a host ^{and} attractant interaction has not been studied.

Artificial Wounds - Collections of screwworm eggs are needed to determine the efficiency of the sterile fly release program as it proceeds into new areas of Central America. The development of a system to duplicate animal wounds is becoming more imperative not only because of the high cost of maintaining wounded animals but also because of recent legislation and public concern about using animals for research purposes. Initial attempts to develop a workable model of an artificial wound has been hindered by the lack of information about ovipositional and feeding stimuli. Some screwworm eggs have been collected by using meats placed inside a heated unit. However, oviposition by other blow fly species has reduced the efficiency of these devices. When information becomes ^{new} available on the factors that influence egg deposition, ~~more serious~~ attempts to develop an artificial device to collect eggs will be pursued. Presently, a trap designed to be attached over the wound of the sentinel animal is being used ^{to} collect flies responding to the wound.

Plant Attractants - Both sexes of screwworm flies have been observed visiting flowers of plants but the actual mechanism of attraction is not known. The flies may visit flowers in response to volatiles and/or color or shape of the blossom. Screwworms have been found primarily on flowers in which the fly could insert its mouthparts. Extrafloral sources were no more attractive than flowers in outdoor cage studies. Certain Acacia species are among the attractive plants and the volatiles (114 total) associated with blossoms of 3 species have been identified. However, attempts to elicit a response to the blossoms (after ^{being} collection ^{ed} fresh and stored frozen) in an olfactometer situation have not been successful. It is not known what effect ^{frozen storage} ~~the sampling of the~~ blossoms has on attractiveness in laboratory tests. Presently, pollen collected from screwworms in Central America is being identified to establish the primary plants visited by screwworms in a tropical environment.

Other Attractants - The response to any of the above attractants may ~~will~~ be explained by a feeding response and, if physiological conditions for the ~~screwworm~~ female and the nutrient source (ie. the wound) are correct, oviposition may occur. In Costa Rica, a ⁿ~~screwworm~~ adult feeding station containing rotting liver has attracted significantly more ~~flies~~ than a wounded animal.

Screwworms

5. Results for Objective 2. Identification of Needed Research

A. Swormlure:

1. [→]Analyze volatiles of SL-4 with time to improve chemical formulation.
2. Test grouping of chemicals to improve effectiveness.
3. [↑]Trap design and formulation for slow release.

Improve

B. Wound Attractants

1. [→]Is swormlure as effective as wounded animals, liver feeding stations, or dried blood?
2. Define host related phenomena
 - ← a. Attraction
 - ← 1) Develop bioassay.
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 - ← b. Stimuli (whole animal concept)
 - ← 1) Biological
 - 2) Physical
 - 3) Chemical

3. Wound Ecology

See previous groups etc

- a. Larval effects
- b. Bacterial effects
- c. Host physiology

C. Artificial Wounds

1. Ovipositional and feeding stimuli
 - a. Chemical aspects (to include fresh whole blood).
 - b. Physical aspects
 - c. Behavioral aspects (physiological controls).
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D. Plant Attractants

1. Determine (identify) plants most frequently visited.
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6. Results for Objective 3. Priorities and Interaction.

1. Test effectiveness of SL-4 in comparison with wounded animals, liver feeding stations, and dried blood in the 3 different ecological zones of Central America. ^(See 5, B.1 above)
To be ~~done~~ ^{carried out} in Costa Rica through ^{with} cooperative effort of ARS and APHIS ~~locations~~ in Mexico.

Should Fargo + Costa Rica contribution be reversed?

2. Define host related phenomena. ⁵ (B.2) Long term project with probable interaction ^{with} Fargo (such as the development of a wind-tunnel study) and Costa Rica (biological and physiological aspects) laboratories with cooperation of *ARS in Mexico laboratory.*

3. Wound ecology. ⁶ (B.3) Medium term commitment with primary work proposed for Fargo (with the possibility of the assistance of a microbiologist) and the cooperation of ~~the~~ ^{ie} ARS Mexico ~~laboratory.~~

4. Improvement of swormlure. ⁵ (A.1-3) Dependent on results of Priority 1 (ie. if swormlure shows potential).

5. Artificial wounds. ⁵ (C.1-2) Low input - sideline activity with field studies in Mexico and Costa Rica.

6. Plant attractants. ⁵ (D.1-3) ~~Plant screwworm adult~~ ^{Adult screwworm - plant} relationships are important in population ecology studies in Central America; significant results could increase priority for attractancy ~~relationship.~~

further

studies

APPENDIX ^I A

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Mrs. Pat Kral can provide addresses if you need them.

Action?

SUMMARY OF ARS SCREWORM ATTRACTANTS WORKSHOP

Fargo, ND, Oct. 4-5, 1988

1. Executive Summary:

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Researcher's for future action

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3. Participants: See Appendix 1.

4. Results for Objective 1. Review of Present Status

Swormlure - Currently, a wind-oriented trap (WOT) baited with swormlure-4 (SL-4) is the standard screwworm trapping system utilized by the research and eradication programs to trap male and female screwworms. However, this system, which performed adequately in more arid environs, does not appear to be as effective in the more tropical areas. Swormlure is the primary attractant ingredient used in SWASS, deployed for screwworm population suppression at critical times. The evolution of SL-4 and results of unpublished research were discussed. SL-4 is the most effective swormlure formulation developed and is 35-50% more

Agenda 2

approach

laboratory

effective than SL-2. Apparently, all 10 components of the SL-4 chemical mixture are necessary as omission of any one results in a 50% reduction in effectiveness. Attempts to incorporate SL-4 into slow-release formulations have not been successful, probably because of the caustic nature of the chemical components. The attraction mechanism (plant or animal related) of swormlure is uncertain. CSIRO scientists in New Guinea are also using SL-4 but with a different trap design; their data indicate that the trapping system is less effective than wounded animals for collecting *Chrysomya bezziana*, the Old World screwworm. Neither ARS nor CSIRO have current efforts to improve swormlure.

Wound Attractants - In the field, female screwworms respond to animal wounds for oviposition and feeding. In the lab, gravid or vitellogenic non-fed (protein source) females have demonstrated a response to wound fluids, air passed over active wounds, navel cord preparations, culture preparations of the bacterium *Providencia rettgeri*, and dried bovine blood. No olfactory response was reported for fresh wounds or whole blood. The results suggest an involvement of bacterially generated products. The least variable and most linear dosage related response was elicited with the dried blood. For this reason and due to the ample supply of the product, subsequent research has utilized the dried blood as the standard for laboratory studies. Basically total activity of the blood can be recovered in steam distillate preparations and after HPLC fractionation of the distillate, 4 active HPLC fractions appear to be synergistic in combinations. Preliminary tests with dried blood preparations have not demonstrated attraction in the field. The role of a host-attractant interaction has not been studied.

Artificial Wounds - Collections of screwworm eggs are needed to determine the efficiency of the sterile fly release program as it proceeds into new areas of Central America. The development of a system to duplicate animal wounds is becoming more imperative not only because of the high cost of maintaining wounded animals but also because of recent legislation and public concern about using animals for research purposes. Initial attempts to develop a workable model of an artificial wound has been hindered by the lack of information about ovipositional and feeding stimuli. Some screwworm eggs have been collected by using meats placed inside a heated unit. However, oviposition by other blow fly species has reduced the efficiency of these devices. When information becomes available on the factors that influence egg deposition, more serious attempts to develop an artificial device to collect eggs will be pursued. Presently, a trap designed to be attached over the wound of the sentinel animal is being used collect flies responding to the wound.

Plant Attractants - Both sexes of screwworm flies have been observed visiting flowers of plants but the actual mechanism of attraction is not known. The flies may visit flowers in response to volatiles and/or color or shape of the blossom. Screwworms have been found primarily on flowers in which the fly could insert its mouthparts. Extrafloral sources were no more attractive than flowers in outdoor cage studies. Certain Acacia species are among the attractive plants and the volatiles (114 total) associated with blossoms of 3 species have been identified. However, attempts to elicit a response to the blossoms (after collection fresh and stored frozen) in an olfactometer situation have not been successful. It is not known what effect the sampling of blossoms has on attractiveness in lab tests. Presently, pollen collected from screwworms in Central America is being identified to establish the primary plants visited by screwworms in a tropical environment.

Other Attractants - The response to any of the above attractants may well be explained by a feeding response and, if physiological conditions for the screwworm female and the nutrient source (ie. the wound) are correct, oviposition may occur. In Costa Rica, a screwworm adult feeding station containing rotting liver has attracted significantly more flies than a wounded animal.

5. Results for Objective 2. Identification of Needed Research

A. Swormlure:

1. Analyze volatiles of SL-4 with time to improve chemical formulation.
2. Test grouping of chemicals to improve effectiveness.
3. Trap design and formulation for slow release.

B. Wound Attractants

1. Is swormlure as effective as wounded animals, liver feeding stations, or dried blood?
2. Define host related phenomena
 - a. Attraction
 - 1) Develop bioassay.
 - 2) Sampling and collecting potential volatiles.
 - 3) Isolation and identification of chemicals responsible for response.
 - 4) Synthesis and formulation of chemicals with attractant properties.
 - 5) Field evaluation of attractant chemicals.
 - b. Stimuli (whole animal concept)
 - 1) Biological
 - 2) Physical
 - 3) Chemical

3. Wound Ecology

- a. Larval effects
- b. Bacterial effects
- c. Host physiology

C. Artificial Wounds

- 1. Ovipositional and feeding stimuli
 - a. Chemical aspects (to include fresh whole blood).
 - b. Physical aspects
 - c. Behavioral aspects (physiological controls).
- 2. Design concepts (mechanical aspects).

D. Plant Attractants

- 1. Determine (identify) plants most frequently visited.
- 2. Identify stimuli responsible for response (ie. color, shape, odor, etc.).
- 3. Apply procedure used for wound attractant attraction components as applicable leading to field evaluation.

6. Results for Objective 3. Priorities and Interaction.

- 1. Test effectiveness of SL-4 in comparison with wounded animals, liver feeding stations, and dried blood in the 3 different ecological zones of Central America. (B.1 above) To be done in Costa Rica through cooperative effort of ARS and APHIS locations in Mexico.
- 2. Define host related phenomena. (B.2) Long term project with probable interaction of Fargo (such as the development of a wind-tunnel study) and Costa Rica (biological and physiological aspects) labs with cooperation of Mexico lab.
- 3. Wound ecology. (B.3) Medium term commitment with primary work proposed for Fargo (with the possibility of the assistance of a microbiologist) and the cooperation of the Mexico lab.
- 4. Improvement of swormlure. (A.1-3) Dependent on results of Priority 1.
- 5. Artificial wounds. (C.1-2) Low input - sideline activity with field studies in Mexico and Costa Rica.
- 6. Plant attractants. (D.1-3) Plant-screwworm adult relationships are important in population ecology studies in Central America; significant results could increase priority for attractancy relationship.

APPENDIX 1

LIST OF WORKSHOP PARTICIPANTS

Adams, T.S.	Research Entomologist	ARS, Fargo, ND
Ashley, T.	Entomologist	APHIS, Tuxtla-Gtz., Mexico
Bram, R.A.	NPS	ARS, Beltsville, MD
Flath, R.A.	Research Chemist	ARS, Albany, CA
Friese, D.D.	Research Entomologist	ARS, Tuxtla-Gtz., Mexico
Gassner, G.G.	Research Geneticist, RL	ARS, Fargo, ND
Gersabeck, E.	Entomologist	APHIS, Tuxtla-Gtz., Mexico
Hammack, L.	Research Entomologist	ARS, Fargo, ND
Hofmann, H.C.	Staff Entomologist	APHIS, Mexico City, Mexico
Mackley, J.W.	Entomologist	APHIS, Tuxtla-Gtz, Mexico
Mangan, R.L.	Research Entomologist, RL	ARS, Tuxtla-Gtz., Mexico
Parker, F.D.	Research Entomologist	ARS, San Jose, Costa Rica
Peterson, R.D.	Research Entomologist	ARS, Fargo, ND
Pomonis, J.G.	Research Chemist	ARS, Fargo, ND
Schmidt, C.H.	Research Entomologist	ARS (Ret), Fargo, ND
Tumlinson, J.H.	Research Chemist	ARS, Gainesville, FL
Whitten, C.J.	Research Entomologist	ARS, Fargo, ND

McDonald, I L

purge

- Executive summary

1ST item

Purged.

Action?

Command?

Posted: Mon Oct 17, 1988 10:30 AM EDT
From: SWR.FARGO
To: RBRAM
CC: SWR.FARGO
Subj: DRAFT OF WORKSHOP SUMMARY

Msg: IGII-2705-5537

SUMMARY OF ARS SCREWORM ATTRACTANTS WORKSHOP

Fargo, ND, Oct. 4-5, 1988

1. Workshop Objectives:

1. To review the present status of screwworm attractants research,
2. To identify new areas of research which will produce technologies applicable to the screwworm eradication program,
3. To establish priorities and define requirements for the successful completion of this research.

2. Participants: See Appendix 1.

3. Results for Objective 1. Review of Present Status

Swormlure - Currently, a wind-oriented trap (WOT) baited with swormlure-4 (SL-4) is the standard screwworm trapping system utilized by the research and eradication programs to trap male and female screwworms. However, this system, which performed adequately in more arid environs, does not appear to be as effective in the more tropical areas. Swormlure is the primary attractant ingredient used in SWASS, deployed for screwworm population suppression at critical times. The evolution of SL-4 and results of unpublished research were discussed. SL-4 is the most effective swormlure formulation developed and is 35-50% more effective than SL-2. Apparently, all 10 components of the SL-4 chemical mixture are necessary as omission of any one results in a 50% reduction in effectiveness. Attempts to incorporate SL-4 into slow-release formulations have not been successful, probably because of the caustic nature of the chemical components. ^{2 volume necessary} The attraction mechanism (plant or animal related) of swormlure is uncertain. CSIRO scientists in New Guinea are also using SL-4 but with a different trap design; their data indicate that the trapping system is less effective than wounded animals for collecting _____, the Old World screwworm. Neither ARS nor CSIRO have current efforts to improve swormlure.

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or whole blood. The results suggest an involvement of bacterially generated products. The least variable and most linear dosage related response was elicited with the dried blood. For this reason and due to the ample supply of the product, subsequent research has utilized the dried blood. Basically total activity of the blood can be recovered in steam distillate preparations and after HPLC fractionation of the distillate, 4 active HPLC fractions appear to be synergistic in combinations. Preliminary tests with dried blood preparations have not demonstrated attraction in the field. The role of a host-attractant interaction has not been studied.

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Wound tunnel } *Biological & physiological aspects in*
Costa

3. Wound ecology. (B.3) (Medium term commitment with primary work proposed for Fargo.)

with cooperation of Tusla microbiology

4. Improvement of swormlure. (A.1-3) (Dependent on results of Priority 1.)

if swormlure shows potential

5. Artificial wounds. (C.1-2) (Low input - sideline activity with field studies in Mexico and Costa Rica.)

6. Plant attractants. (D.1-3) (Plant-screwworm adult relationships are important in population ecology studies in Central America; significant results could increase priority for attractancy relationship.)

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Gersabeck, E.	Entomologist	APHIS, Tuxtla-Gtz., Mexico
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Mangan, R.L.	Research Entomologist, RL	ARS, Tuxtla-Gtz., Mexico
Parker, F.D.	Research Entomologist	ARS, San Jose, Costa Rica
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